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The relationship between university and industry in the knowledge economy: a case study of Thailand's automotive cluster

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The relationship between university and industry in the knowledge economy

A case study of Thailand's automotive cluster

Jomphong Mongkhonvanit

A thesis submitted for the degree of Doctor of Business Administration

University of Bath

School of Management

June 2008

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Abstract

This study examines the linkages and factors influencing relationships between universities and companies in Thailand's automotive cluster and seeks applicable models and ways to improve the linkages among government, universities, national research institutions and firms in order to enhance innovation and competitiveness in the industry. Based on the ideas of the knowledge economy and a "triple helix model" of relationships among government-industry-university, this study uses multiple data collection methods, including questionnaires and in-depth interviews, with descriptive analysis to investigate the relationship among government, university and industry in Thailand's automotive cluster in Samutprakarn province which emerged in 1990s to become a leading industrial sector of the country that the government has emphasized on.

Findings from this research show universities, as important players in the knowledge-based cluster, have three major schemes to serve the cluster, in collaboration with government, organization/institute and industry. Those are 1) to produce graduates highly relevant to the need of related sectors and 2) to conduct basic and applied research, and 3) to collaborate with organization/institute and industry to create new technology/innovations. However, there are challenges for any university to substantially support the cluster. These challenges are 1) universities do not produce highly qualified and industrially relevant graduates, 2) universities do not understand and accommodate the nature of industry, 3) universities do not have sufficient resources, 4) universities are not recognized as a critical player in economy, and 5) universities do not seriously cooperate among themselves and with other related sectors.

To deal with the challenges above and to enhance universities' competitiveness/relevance in the automotive industry, my study recommends that universities could be improved by establishing a track record, culture and strategic plan to enhance trust and mutual recognition from the Thai automotive cluster. It is this trust and recognition that could lead to collaboration and eventually transform the automotive cluster into a knowledge-based and competitive cluster. In the longer-term, universities that adopt a mission to serve industry should be developed to become an effective component of the 'triple helix' or an entrepreneurial university by 1) committing themselves towards collaboration with industry and other players for mutual benefit and industrial growth, 2) understanding the demands and culture of industry, 3) developing niche technology and translating this into patents/licensing, 4) providing consultancy and collaborating with industry and government through an entrepreneurial spirit, 5) supporting business incubation services and spin-offs, 6) enhancing continuity of cooperative and entrepreneurship education, 7) recruiting and developing industrially-experienced and research-active staff, and 8) accommodating competitive facilities for R&D. In addition, a governmental intermediate organization (such as Thailand Automotive Institute) should be identified as the central organization in improving competitiveness of the

cluster that should be given greater autonomy and flexibility to support the coopetition of different players with greater efficiency and effectiveness

Abbreviations

ANFAVEA	Brazilian Motor Vehicle Manufacturers Association
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
BIOTEC	National Centre of Genetic Engineering and Biotechnology
BTG	British Technology Group
CBU	Complete Build Up
CIS	Community Innovation Survey
CKD	Complete Knock Down
CSR	Context for firm Strategy and Rivalry
CV	Commercial Vehicle
DTI	Department of Trade and Industry
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GM	General Motor
ICT	Information and Communication Technology
IMF	International Monetary Fund
JAMA	Japanese Automobile Manufacturer Association
JV	Joint Venture
KBE	Knowledge-Based Economy
KMITL	King Mongkut's Institute of Technology Ladkrabang
MNC	Multinational Company
MTEC	Thailand's Metal and Materials Technology Centre
NANOTEC	National Nanotechnology Centre
NBIC	North Bangkok Innovation Cluster
NECTEC	National Electronics and Computer Technology Centre
NICs	Newly Industrialized Countries
NIH	National Institute of Health
NSTDA	National Science and Technology Development Agency
OECD	Organisation for Economic Cooperation and Development
OEMs	Original Equipment Manufacturers
PC	Passenger Car

PT	Pure Thai
PV	Pick-up Vehicle
QA	Quality Assurance
R&D	Research and Development
REMs	Replacement Equipment Manufacturers
RSI	Related and Supporting Industry
SKD	Semi-Knock Down
SME	Small and Medium Enterprise
SWOT	Strength Weakness Opportunity and Threat
TA	Technical Assistance
TAI	Thailand Automotive Institute
TAIA	Thai Automotive Industry Association
TAIS	Thai Automotive Innovation System
TAPMA	Thai Auto Parts Manufacturing Association
TDRI	Thailand Development Research Institute
TNC	Transnational Corporation
TSAE	Thailand's Society of Automotive Engineer
U-I-G	University-Industry-Government
UK	United Kingdom
UNIDO	United Nations Industrial Development Organization
US	United State
USO	University Spin-Off
WTO	World Trade Organization

Chapter 1

Introduction: The Problem and Its Setting

1.1 Introduction

Since the economies of the industrialized countries have become more knowledge-based, universities have become viewed as important players in regional economic development. A survey in the “Economist” suggested the concept of the knowledge-based economy serves to “portray the university not just as a creator of knowledge, a trainer of young minds, and a transmitter of culture, but also as a major agent of economic growth: the knowledge factory, as it were, at the centre of the knowledge economy” (David, 1997: 4). From this perspective, universities are expected to support the emergence of dynamic regional industrial clusters and, thus, act as crucial contributors to regional economic development.

In the knowledge-based economy, ideas and intellectual capital have replaced natural resources and mechanical innovations that previously served as the driving force of economic growth. The university has become more critical than ever as a provider of talent, knowledge, and innovation in the age of knowledge-based capitalism. It provides these resources largely by conducting and publishing research and by producing graduates to serve the industries. The university is further empowered by generating new and significant discoveries to increase its status. In this way, academic research differs markedly from the profit-motive and private-user driven industrial research and development.

In order to generate new discoveries and assume a more prominent position, a university engages in a productive competition with other counterparts for the most respected academics. An academically excellent faculty, in turn, attracts outstanding students and enhances the university’s reputation. The pursuit of excellence is reflected in the university’s contributions to a new body of knowledge, typically embodied in academic research.

In recent times, the university's tie to industry has grown extensively. Industry has become more involved in sponsoring research, whilst universities have additional functions such as licensing their technology and creating spin-off companies to raise funds due to intensive competition and increasingly limited funds from government (Florida, 1999).

This seemingly beneficial trend has afforded universities and industry a new and unique opportunity as the changing waves of the knowledge economy continue to have an impact on what some economists refer to as the forces of creative destruction. These forces create opportunities for the establishment of a new industrial sector or a new technology as a replacement for existing industries. These forces also enhance a knowledge-centred economic region and opportunity for universities to participate in the stream of development progressing through scientific and technological advancement.

From the many reasons implied, universities and industry could benefit from such a relationship to achieve their mutual missions. This study will identify the "dynamics" that exist between universities and industry in emerging regional development. In addition, it will examine the relationship of players in a geographical cluster and how to further facilitate and enhance relationships to increase competitiveness.

1.2 Background of the study

1.2.1 The industry

The Thai automotive cluster's performance has been the most dominant among Southeast Asian Countries. This domination is the result of the continuous influx of direct investments made by nearly all of the world's largest automotive companies to locate their manufacturing facilities in Thailand (Porter, 2003: 27).

Among ASEAN, Thailand has one of the largest automotive assembling capacities, and possibly the highest quality parts manufacturing capability. These, combined with a sizeable domestic market, market growth potential, stable political atmosphere, liberal trade and investment policy, absence of ethnic conflicts, and the lack of a "national car programme", have made Thailand one of the most attractive countries

for automotive investments. As the Thai auto industry has matured, the industry has grown from being import-substitution to become an export-oriented industry. At present, the automotive industry is Thailand's third largest industry, employing an estimated total workforce of about 225,000 employees, with a total production capacity of 1,270,100 cars and trucks per year (The Office of Industrial Economics, 2006: 17).

Table 1: Capacity of the Thai automotive industry, from 2000 to 2005

Year	Cars		Million Baht	
	Production Volume*	Sales Volume*	Export Value*	Import Value**
2000	1,537,444	1,051,043	83,481	79,107
2001	1,669,413	1,198,757	107,639	88,343
2002	2,562,095	1,740,442	109,611	99,253
2003	3,175,188	2,300,036	141,075	130,407
2004	3,956,151	2,665,418	215,082	148,710
2005	4,619,328	2,815,834	307,241	161,634
Growth 2005/2004	16.76%	5.64%	42.85%	8.69%

Source: * The Federation of Thai Industry, 2000-2005

** Department of Trade Negotiation, Ministry of Commerce, 2000-2005

An assessment of the business environment of the Thai automotive industry based on Porter's Diamond Model finds that the industry is relatively competitive to some similar economies due to a good physical infrastructure, a large presence of capable locally based suppliers that are clustered together in the same geographical location, government policy supporting the industry as top of the priority list of the country and an enabling context and rules for foreign direct investment. These positive conditions have propelled the industry's continual development and expansion resulting in one of Asia's largest automotive production bases. However, the progress and past success have been primarily based on low cost factor impact. Low labour costs allow Thai assembly plants to be cost competitive despite a much lower level of automation. This phenomenon provides local suppliers with little incentive to adopt world-class

technology to improve productivity and they perpetuate low wages. In the long term, this type of development is not sustainable due to the cost and incentive competition from many countries (Porter et.al, 2003: 28).

Taken into account the challenges mentioned, the concept of a Thai automotive cluster has been formed to increase competitiveness among firms and players belonging to such a cluster. The cluster development is a collaborative process involving government at multiple levels, companies, universities (teaching and research institutions), and institutions for collaboration, and is congruent to the *triple helix* explanation of university-industry-government relations (Etzkowitz and Leydesdorff, 2006). The government-sponsored Michael Porter's suggestion arising from the assessment of the business environment of the Thai automotive industry is that Thailand must pursue the following two sets of strategies to ensure the sustainability of its automotive industry (Porter, 2003: 28-29).

- 1) Encourage multinational automotive companies to expand their business in Thailand by revamping the business environment for higher productivity. This can be achieved by improving the capability and productivity of local suppliers, particularly in the second and lower tiers, in order to develop more enabling mechanisms for technology transfer and assistance from locally-based multinational firms.
- 2) Upgrade the competitiveness of local suppliers by building more advanced capabilities to support higher value-added activities. The suggestions are:
 - 2.1) Institutionalizing the productivity improvement practices, e.g. institutionalizing modern plant management practices, productivity improvement culture, business, and production process streamlining, effective human resource development systems, etc.
 - 2.2) Promoting and building capacity for research and development through the persuasion of local suppliers to think in the long-term and initiate research and development activities. Effectively and commercially viable research and development must be private sector led and sponsored by technical assistance from the academic and research institutions. In addition, the industry needs to develop expertise in automotive engineering to competently conduct the actual research and

development initiatives. The career paths and incentive schemes of the experts must be restructured.

- 2.3) Strengthening the linkage and development of upstream- supporting industries. The development of upstream- supporting industries must be tailored into two main groups: 1) the mold and die and tools manufacturers and 2) the material manufacturers e.g. steel, rubber, plastic, etc.

1.2.2 The university

According to the Commission on Higher Education of Thailand (2007), Thai universities' functions are:

- 1) To produce graduates with high-level professional skills and moral integrity to meet the need for human resources;
- 2) To generate new knowledge through research and scholarship to strengthen the regional and national economics of self-reliance and international competitiveness;
- 3) To provide academic and technical services to state and private enterprises through research training and consultancy activities in order to ensure an efficient transfer of necessary and appropriate technology for social and economic development at regional and national level;
- 4) To conserve and promote the traditional arts and culture of the region and the nation so that the university is perceived as a model centre of community life worthy of emulation.

The role of universities to actively collaborate with co-located companies and other institutions in the Thai automotive cluster is to pursue their position as an active and essential part of the regional business environment. The different objectives of universities and companies need to be managed to achieve mutual goals and interests. The roles of universities are in generating new knowledge and transferring knowledge, workforce development, and facilitating competitive initiatives.

The most important form of university and industry linkage is the flow of university graduates to the market as well as the flow of new knowledge generated by

university-based research through public channels. The traditional missions of universities, in many cases, are expanded to include regional and economic development, which includes consultation with the industry, patent licensure, technology- service contracts, joint research projects, university-based science parks, and university affiliated enterprises.

The several studies of Thai firms conducted since the 1980s state that most firms have grown without deepening their technological capabilities in the long term, and their technological learning has been very slow and passive (Bell and Scott-kemis, 1985; Chantramonklasri, 1985; TDRI, 1989; Dahlman and Brimble, 1990, Tiralap, 1990; Mukdapitak, 1994; Lall, 1998). The recent World Bank study (Arnold, 2000) also confirms this long-standing feature of Thai firms. Only a small minority of large subsidiaries of Transnational Corporations (TNCs), large domestic firms and SMEs has capability in R&D, while the majority is struggling with increasing their design and engineering capability (Intarakumnerd and Chairatana, 2003: 8).

Termittaya's study (2006) shows the survey data of relationships between the firms and the universities in Thailand. The firms do not have a strong interest in university-industry linkages. The data show that more than 70 percent of firms had identified clients as external information sources they had intensively collaborated with. Around 61 percent of firms identified the parent/associate companies. Around 61 percent and 60 percent of firms identified locally-owned suppliers and foreign-owned suppliers respectively as their external information sources. The paper concludes that university – industry linkages played a minor role in building the technology/innovation capability of firms.

Focusing on Thai universities nowadays, one will find that they have rather poor research capability and most of their research has a low level of industrial relevance (Intarakamnerd and Tangchitpiboon, n.d.: 16). Meanwhile the linkage between industry and universities is rather weak because it is based on personal connections between individual researchers and companies rather than organization commitments (Brooker Group, 1995: 19).

A recent study by the College of Management of Mahidol University summarizes the gaps in industry-academia collaboration. It demonstrates the weaknesses of both

sides, which obstruct meaningful collaboration (Table 2) (Intarakumnerd and Chairatana, 2003: 10-11).

Table 2: Gaps in industry-academia collaboration

Industries	Gaps	Academia
• Passive actors in initiating cooperative projects	• Lacking continuous cooperative projects or activities and motivation for collaboration	• Major activities are not two-way cooperation. Education institutes usually initiate and dominate the relationship.
• No tangible/substantial activities that might lead to collaboration with educational institutes	• Missing the clear goals and objectives of the collaboration	• Linkages are more or less in terms of asking for help than achieving the project together for maximum benefit of both parties
	• Lacking assistants/coordinators who can understand both sides, coach, and foster the relationship	• No substantial linkages in term of R&D projects
	• Lacking analysis of problems from the industry's perspective	

Source: College of Management, Mahidol University, 2003

Thailand's automotive cluster is regarded as an important economy to be focused in the national agenda and was targeted to become the Detroit of Asia through part of the industrial policy announcement by the national government in 2003, while foreign assemblies and part-producers play dominant roles in the industry.

According to the various studies such as those above, it is interesting to study the dynamic of players within the automotive cluster and the linkages between university and industry in the knowledge-based economy whilst exploring opportunity to improve such linkages for the enhancement of industrial competitiveness.

From the existing literatures and previous studies on industry-university collaboration (as seen in chapter 2), there is limitation of knowledge on roles and dynamics of the two players in development of knowledge-based industrial cluster in developing countries. In this research, I thus explore the dynamic aspects of the relationship,

benefits and opportunities of both players emanating from the industrial cluster in facilitating the linkage between universities and industry and how to further enhance the relationship to increase their competitiveness. I strongly believe that this research will contribute to the body of knowledge in the field of higher education, business, university-industry-government interaction, organizational development, public policy, competitive strategy and economic development.

1.3 Research objectives

- 1) To investigate the linkages and relationships between universities and industry in relation to the knowledge economy.
- 2) To find applicable models and ways to improve the linkages in order to enhance industrial competitiveness.

1.4 Research questions

The main questions to be answered in the study of the relationship between university and industry in the knowledge economy are the following:

- 1) What is the nature of the linkages and relationships between university and industry in Thailand's Automotive Cluster?
 - i. What are the factors and their significance in determining such relationships?
 - ii. To what extent do universities serve automotive industrial needs? Why is it the case?
- 2) What recommendations can be made to address the problems in university-industry linkages and to improve relationships to better serve the economy?
 - i. How could universities improve to better serve Thailand's Automotive Cluster in enhancing competitiveness and sustainability?

1.5 Theory for the research

The research study will utilize the Triple Helix model as the major framework for understanding and analyzing the relationship between Thai universities and the Thai

automotive cluster. The Triple Helix model, popularized by Etzkowitz and Leydesdorff (1997), emphasizes the increased interaction among various institutional actors in industrial economies' innovation systems, specially universities, industry, and government. There are tri-lateral networks among three spheres/institutions while each sphere takes on roles of the others as they become hybrid organizations.

1.6 Significance of the study

- 1) The results of this study will make known the current dynamics of relationships between universities and the automotive cluster. The results of this study will inform the emergence of mechanisms for the universities' and industry's transferral of knowledge and competencies.
- 2) The result of this study may also help to strengthen linkages between the automotive industry and universities as a foundation for knowledge generation and technology catching-up.
- 3) The result of this study will add to the limited knowledge on knowledge-based clusters in emerging economies.

1.7 Scope and delimitation of the study

- 1) This study will be limited to the automotive industries in Samutprakarn's cluster, which will be divided into two groups; auto-assemblers and auto-producers (multinational corporations, joint-ventures, and pure Thai companies).
- 2) The sample of universities is determined by proximity to the cluster, reputation and quality of their automotive engineering faculty. The university which belongs to Samutprakarn's automotive cluster is King Mongkut's Institute of Technology Ladkrabang (KMITL). Those which do not belong to Samutprakarn's automotive cluster consist of 1) Chulalongkorn University, the first and foremost public university in Thailand, where Thailand's Association for Automotive Engineering (TASE) is located; 2) King Mongkut's Institute of Technology North Bangkok, King Mongkut's University of Technology Thonburi, Rajamangala University of Technology

Thanyaburi, and Rajamangala University of Technology Phra Nakhon North Bangkok, which are all well-regarded technological universities with good reputations in mechanical and automotive engineering; 3) Mahanakorn University of Technology, a private university known for its engineering school in international rankings; and 4) Siam University, a comprehensive private university;

- 3) The other institutions to be researched are the automotive-related institutes embracing the National Metal and Materials Technology Centre (MTEC), the research institute related to the Thai automotive industry, and the Thailand Automotive Institute (TAI), Thai Auto-Parts Manufacturers Association (TAPMA), Thailand's Society of Automotive Engineering (TSAE), and Thai Automotive Industry Association (TAIA);

1.8 Definitions of terms

Given that diverse meanings are sometimes attributed to specific terms, it is essential to define terms that are used throughout this thesis. The following terms are discussed and expanded in different sections of this thesis:

- **Knowledge economy** can be characterized in terms of the increasing role of knowledge as a factor of production and its impact on skills, learning, organization, and innovation.
- **Globalization** can be summarized in terms of impacts relating to the emergence of a global system of economy and society, global competition, the location, organization, and rationalization of economic activity.
- **Cluster** means a geographically proximate group of interconnected companies and associated institutions in a particular field, including product producers, service providers, suppliers, universities, and trade associations. The characteristics of clusters are the following:
 - A critical mass of firms and institutions, located in the same area and specializing in a specific economic activity;
 - Closeness of firms due to the basis of geography, organization, culture, and interest;
 - Firms specializing in different aspects of the value chain;

- Interdependent, complementary firms generating multiple, overlapping networks of activity, learning and social links;
 - Firms with trading and non-trading based relationships;
 - Public and private institutions and organizations able to support the growth of cluster.
- **I-U-G Relationship** means automotive industry-universities-government-other related organizations linkages which have both formal and informal patterns. Direct industry-university linkage is the direct relationship of automotive industry and universities, while indirect linkages are the industry-university relationship through government and/or other related organizations-automotive industry. Such relationship benefits the creation of new knowledge, innovation development and social capital for quality of graduates and competitiveness of industry.
 - **University and firm collaboration** can be characterized in terms of:
 - The engagement of university and firm (firm engaged in collaboration with the university and the university more engaged in the upgrading of its business environment);
 - The mission and goal statement of university and industry;
 - The functions of university and firm;
 - The key roles for university to generate knowledge and transfer knowledge, workforce development, and facilitation of competitiveness initiatives;
 - Higher degree of attraction for staff and students;
 - Higher impact of research and education.
 - **Cluster's competitiveness** means the degree to which firms can survive in the knowledge-based economy through development of their productivity, effectiveness, efficiency and innovation using codified and tacit knowledge.
 - **Triple Helix Model** is a model analyzing the linkage between universities, government, industries, and revolving organizations. This model emphasizes the increased interaction among various institutional actors in industrial economies' innovation systems, especially universities, industry, and government. There are tri- lateral networks among three spheres/institutions while each sphere takes role of the other as they become hybrid organizations.

- **Coopetition** can be characterized as a business strategy based on a combination of cooperation and competition, derived from an understanding that business competitors can benefit when they work together.
- **Innovation system** can be summarized in terms of a network of public and private institutions within an economy that fund and perform R&D, translate the results of R&D into commercial innovations, and affect the diffusion of new technologies.
- **University's demand (needs)** can be summarized in term of the universities' requirement in various forms from industry or other related organizations such as funding, equipment support, technology transfer, etc. for production development.
- **Universities' supply (services)** can be summarized in term of universities' services serving social and industrial needs derived from universities' missions such as producing relevant graduates, conducting useful research, participating in regional development, etc.
- **Cooperative programme** means a work-integrated education program resulting from collaboration between educational institutes and enterprises that allows students to apply their knowledge in the classroom to the field work, and vice versa.

1.9 Outline of report

The thesis is divided into 5 chapters to serve the purposes of study as the following:

- Chapter 1 serves as an orientation and background of the thesis
- Chapter 2 provides the discussion of the theoretical background and contexts to the study including literature review on 1) Knowledge-Based Economy (KBE), 2) Universities and their roles in KBE, 3) Universities' functions within an innovation system , 4) Triple Helix of University-Industry-Government (U-I-G) relations in KBE, and 5) 'Coopetition': a framework for competitiveness; while conceptual framework for this study is discussed
- Chapter 3 explains and discusses the research design and methodology chosen for this research study

- Chapter 4 provides the study's results and findings
- Chapter 5 contains the analysis and discussion of results and findings
- Chapter 6 provides recommendations and conclusion of the study

Chapter 2

Literature Review and Conceptual Framework

According to the objectives of this study, this review of related literature and studies focuses on 1) Knowledge-Based Economy (KBE), 2) Universities and their roles in KBE, 3) Universities' functions within an innovation system, 4) Triple Helix of University-Industry-Government (U-I-G) relations in KBE, and 5) 'Coopetition': a framework for competitiveness. This study's conceptual framework incorporates the theories and concepts of globalization and knowledge-based economy, coopetition and triple helix of U-I-G relation in which will be discussed in this chapter. These are provided with information, arguments and understanding as follows:

2.1 Knowledge-Based Economy (KBE)

2.1.1 Emergence of KBE

The knowledge economy is emerging from two defining forces: the rise in **knowledge intensity** of economic activities, and the **globalization** of economic affairs. The revolution of information and communication technology (ICT) is instrumental in bringing about greater knowledge intensity, globalization and technological changes accommodating the era of the knowledge economy. Meanwhile, globalization has been driven by additional instruments such as national and international deregulation to accommodate borderless trade / economic activity, international organizations / agreements and the ICT-related communications revolution. However, it is important to note that the term "Knowledge Economy" refers to not only an aspect of the economy, but also the overall economic structure and a combination of ongoing phenomena (Houghton and Sheehan, 2000: 2).

In economic terms, the central feature of the ICT revolution is the manipulation, storage, and transmission of large quantities of information at very low cost. An equally important feature of these technologies is their pervasiveness. While earlier technological developments focused on particular products or industrial sectors, information technology is, rather, generic in that it has impacts on every sector of the economy: on both goods and services, and on elements of the business chain, from research and development to production, marketing, and distribution. This phenomenon

involves both the increasing knowledge intensity within development and the delivery of different products and services, and the growing potential of those products and services in the economy (Houghton and Sheehan, 2000: 2-3).

The other main driver of the emerging knowledge economy is the rapid globalization of economic activities. With globalization, economic, social and political connections across the globe have been deepening, widening and accelerating while economies across the world have been increasingly integrated. Different information technologies have been rapidly developed to serve a borderless society, and new post-Fordist work practices have widely been implemented (Waters, 1995; Castells, 1996). These developments, along with globalization, configure “*the knowledge economy*”, in which the capacity to compete in the world depends on the development of value-added products and services. There is evidence that the developments of high value-added products and services very much rely on knowledge and innovation.

In the most recent phase, globalization is characterized by rapid increases in the flow of foreign direct investment (FDI), other capital transfers, trade flows of goods and services, and transfer of technology. From these movements, two phenomena are identified. First, in recent years, FDI and other capital flows have grown more rapidly than the trade flows have, suggesting that the current phase of globalization is about capital movement rather than trade. Second, the flows of FDI, other capital movement, trade and technology are becoming increasingly inter-related (Houghton and Sheehan, 2000: 4-5).

These facts have an impact at the level of the individual firm, as firms are increasingly required to adapt to the global environment and adopt new strategies in order to deal with the new realities. Major competitors in all markets become multinationals which enjoy the economy of scale and advanced expertise in production of both goods and services. The growth of multinational corporations and the new nature of world trade, along with roles of various elements in globalization, are all contributing to the transformation of the global economy.

The central characteristics of globalization since the 1980s can be summarized in terms of impacts relating to the emergence of a global system enhanced by global institutions such as World Trade Organization (WTO), global market competition, ICT technology enhancing borderless communication, multinational organizations/ agreements, and a rationalization of economic activity;

while the emergence of the knowledge economy can be characterized in terms of the increasing role of knowledge as a factor of production and its impact on competitiveness (Houghton, 2000: 8-9).

2.1.2 Definition of KBE

The knowledge-based economy is defined by the OECD as a system in which the production, use and distribution of information and knowledge are essential to the process of economic growth (OECD, 1996). In addition, Brinkley (2006) defined the knowledge-based economy in three categories:

- Industrial sector's definition: knowledge intensive industries and services;
- Occupational based definition: knowledge workers;
- Innovation-related definitions: the transfer of innovation among firms/institutions.

Knowledge Economy's Industrial Definition:

The knowledge economy is often thought of and sometimes referred to as the existence of knowledge-intensive industries that require ICT-technology and a highly educated workforce. The industrial definition of the knowledge economy initially focused on manufacturing and often used research and development intensity as an indicator to distinguish among sectors of high, medium, and low knowledge intensity. The definition has steadily expanded to include service industries that invest relatively little in research and development, but are intensive in employing ICT, innovations and a highly skilled workforce (Brinkley, 2006: 14).

Knowledge Economy's Occupational Definition:

In term of the knowledge economy's occupational-based definition, knowledge workers are perceived to be needed across sectors due to the competitive environment demanding skills and knowledge in organizations. However, there are some arguments over the definition of knowledge workers. Brinkley (2006) proposed that there are at least three ways in which we can define knowledge workers:

- All those who work in the top three occupational classifications: managers, professionals, associate professionals;
- All those with high levels of skills indicated by academic credentials and other qualifications;

- All those who perform tasks that require expertise, systematic thinking and complex communication skills with the assistance of ICT.

As Brinkley's paper showed the essential nature of workers' credentials and qualifications, the study fits the conventional OECD view that a key indicator to determine an investment in up-skilling the workforce and building knowledge is the share of GDP devoted to higher education. Regarding the definition of human skills, Levy and Murane (2006) divided human skills into five categories:

- Expert thinking: ability and skills of problem solving when simple/direct solutions do not exist. Computers and ICT can not substitute for workers' expert thinking but can assist through making useful information readily available;
- Complex communication: ability and skills of interacting with other people to acquire or convey information and persuade others. In this regard, examples of those who exploit much of this skill are managers, teachers, sales people;
- Routine cognitive: mental tasks/skills closely described by rules/orders such as routines of processing application forms and claims. These tasks are often either substituted or assisted by computerization and ICT;
- Routine manual: physical tasks described by rules/order, such as assembly line work and packaging. These repetitive tasks, in many circumstances, can also be undertaken by programmed machines;
- Non-routine manual tasks: physical tasks that are difficult to be accommodated by simple rules/orders because they (including truck-driving and cleaning) require optical, cognitive and fine muscle control. Such jobs are unlikely to be assisted or replaced by computers.

Levy and Murane further applied these categories above to the US workforce between 1969 and 1998 and found that jobs requiring complex communication had increased by nearly 14 percent, while jobs requiring expert thinking had increased by over 8 percent. All other jobs requiring routine cognitive tasks and manual tasks were in a declining stage of employment over the same period. There was also a large scale survey carried out by surveying American top companies' executives and managers using a similar approach to identify set of skills that will be most valuable in terms of competitive advantage in the year 2020. The adopted five categories used in the survey that indicate the essence of knowledge factors are:

- Complex knowledge-based roles that are primarily outward facing and require developed communication and judgment skills;
- Complex knowledge-based roles that are primarily inward-looking and require developed communication and judgment skills;
- Simple knowledge-based roles that are rules-based, outward facing and do not require developed communication and judgment skills;
- Simple knowledge-based roles that are rules based, inward facing, and do not require developed communication and judgment skills;
- Production roles directly related to manufacturing or production processes. (Brinkley, 2000:21):

Knowledge Economy's Innovation-related Definition:

Another way to define the knowledge economy is to look at the share of output or employment among firms that introduce new innovations in either process or product. The OECD has adopted a similar approach through three groups of indicators designed to capture three closely related innovation measures: the generation of new knowledge, industry-science linkages, and diffusion of industrial innovation and technology (Freudenburg, 2003):

- Indicators of new knowledge generation: research and development performed by the non-business sector as a share of GDP; non-business researchers per 10,000 labor force; basic research as a share of GDP; PhD graduation in science, engineering, and health; scientific or technical articles per million of population;
- Indicators of industry-science linkages: research and development financed by business sectors and public sector as a percentage of GDP; scientific papers cited in US-issued patents; publications in the nineteen most industrially relevant scientific disciplines per million of population;
- Indicators of industrial innovation: business funded R&D as a share of GDP; commercial researchers per 10,000 labour force; patents in “*triadic*” patent families per million of population; share of firms with new or technologically improved products and processes.

The OECD's study cited in Brinkley (2006) found that the generation of new knowledge strongly correlates with industrial innovations and moderately correlated with industry-science linkages. This paper showed that the standard definition of innovation excluded two other forms of innovation described by the Community Innovation Survey (CIS): “*organizational innovation*” regarding

innovation around work settings and business practices and “*presentational innovation*” covering design and marketing. The survey found a close linkage between these two forms of innovation; in other words, firms that have organizational innovation are more likely to accommodate presentational innovation as well. These “*softer*” innovations (strategy, management, organization, marketing, and aesthetic) may be another key distinctive feature of the knowledge economy, especially around the introduction of knowledge management practices.

Apart from the specific practices/skills enhancing the knowledge economy mentioned above, there is the emergence of knowledge management deploying an effective use of ICT to analyze, process and share information and knowledge among knowledge workers. “*Knowledge management*” practices aim to describe how organizations track, measure, share, and make use of both explicit (codified) and tacit (implicit) knowledge. The OECD identifies the following as key knowledge management practices:

- Creating a knowledge sharing culture;
- Developing policy on incentive to retain knowledge-employees;
- Building alliances for sharing/acquiring knowledge;
- Writing knowledge management policy.

Not only are such practices becoming widespread, but also there is an association of such practices with innovation and productivity.

2.1.3 Significant Changes through the Emergence of KBE

The emergence of the knowledge-based economy has made significant changes in the industrial economy. Those shifts are as follows:

First, the information revolution has intensified knowledge codification, and increased the exchange/transfer of codified knowledge within the knowledge stock of advanced economies. Codification and the transfer of knowledge also reduce the additional and duplicative investment in acquiring similar knowledge. They create bridges among fields and areas of competence, and reduce the scattering of knowledge. (Houghton and Sheehan, 2000: 10).

Second, *flexible organizations* enhanced by new ICT, other innovations and competition are driving and shaping globalization today by merging flexibility, high product quality, and a degree of customization with the speed and low unit costs of mass production. Flexible organizations can reduce waste and increase the productivity of both labour and capital by integrating “*thinking*” and “*doing*” at all levels of their operations. In doing so, they eliminate many layers of middle management, which are dysfunctional in terms of information flow. They also avoid excessive specialization and compartmentalization by defining multi-task job responsibilities (which calls for multi-skilled workers) and by using teamwork and job rotation (Oman, 1996: 19).

Third, investment in knowledge, learning/skills and ICT are complementary with investment in human resources and skills (Soete, 1997). The skills required in the workforce will increasingly be complementary, rather than being substitutes, with information and communication technology. The information technology will be the locus of codified knowledge in the knowledge economy, while work in the knowledge economy will increasingly demand human and tacit skills (Houghton and Sheehan, 2000: 11).

Fourth, regarding innovation and knowledge networks, the knowledge economy is driven by a hierarchy of networks and acceleration of the rate of change and the rate of learning, while the opportunity and capacity to get access to and join knowledge-intensive and learning-intensive networks determine the opportunity and socio-economic position of individuals and firms (OECD, 1996: 14, David and Foray, 1995). Thus, firms compete to become learning organizations that continuously adapt management, organization and skills to accommodate new technologies and grasp new opportunities.

Fifth, according to learning organizations and innovation systems in a knowledge economy, firms will search for linkages to promote inter-firm interactive learning and relationships with outside strategic partners and networks to provide complementary assets. These relationships help firms reduce the costs and risks associated with innovation, gain access to new research findings, acquire key technological components, and share assets/knowledge in manufacturing, marketing and distribution. With the development of new products and processes, firms determine which activities they will undertake individually, which will be the result of collaboration with other players/firms, which will be from collaboration with universities or research institutions, and which will be from the support of government (OECD, 1996: 16). Innovation often comes from the flows and

relationships which exist among industry, government, and academia in the development of science and technology. The “*knowledge distribution power*” of the system, or its capability to ensure timely access of innovators to relevant stocks of knowledge, is therefore a major determinant of prosperity (OECD, 1996: 16; OECD, 1997).

Sixth, regarding global competition and production in the new environment, competitiveness depends increasingly on the coordination and synergy generated among a broad range of specialized industrial financial, technological, commercial, administrative, and cultural skills/capacities which can be located anywhere around the world (Hatzichronoglou, 1996).

Seventh, production is being globally relationalized, with firms combining the factors, features, and skills of various locations in the process of competing in global markets. Globalization is fundamentally a collection of microeconomic phenomena, driven by the strategies and behaviour of different players. In a global strategy, the comparative advantages of each nation, state and location are no longer separately considered. Comparative advantages of a location rather rely and are deployed on a firm’s global strategy due to ICT, knowledge transfer, speed of change and capital flows (Hatzichronoglou, 1996: 5). Nations, states, and locations need to achieve the development of coherent sets of advantages and find a niche in global market with the economic activity they would like to foster.

Eighth, regarding clustering in the knowledge economy, networks and geographical clusters of firms are a particularly important feature of the knowledge economy. Firms find that it is increasingly necessary to work with other firms and institutions to form strategic alliances because of the rising cost, increasing complexity, intensive competition and large scope of technology. Despite improved capability for communication, firms increasingly co-locate because it is the most efficient and effective way to share understanding and tacit knowledge (Cantwell, in DTI, 1999; Devol, 1999: 9).

Ninth, knowledge has fundamentally different characteristics from ordinary commodities and these differences have crucial implications on how the knowledge economy has been organized (DTI, 1999: 5). Indeed, ideas and information exhibit very different characteristics from the goods and services of the industrial economy. Rather than traditional commodities that could not be shared and reused while the cost of production are different over time; the social values of ideas and information can be endlessly shared with and reused by different others. More importantly, the reproduction and

utilization of ideas and information are almost at no cost, while reproduction of traditional commodities does not cost much less due to the use of materials and production process. While up front costs associated with the production of traditional goods such as a car or house may not necessarily be high, each item is still costly to produce. The more of these one produces, the more likely one will eventually encounter scarcities that drive up production costs and reduce the size of social returns. In the case of innovation, ideas and information, however, the opposite would seem largely to be the case. While up front development costs can be very high, the reproduction and transmission costs are low. The more such items are (re)produced, the greater the social return on investment (Industry Canada, 1997).

Traditional economics is founded on a system which seeks to optimize the efficient allocation of scarce resources. However, because of the unique characteristics of information and knowledge the meaning of scarcity in knowledge goods and services is changing. Indeed, the scarcity defying expansiveness of knowledge is the root of one of its most important defining features.

Once knowledge is discovered and made public, there is essentially zero marginal cost to adding more users (DTI, 1999: 6). Knowledge can add value to an otherwise closed, zero-sum system of value (Sigismund, 1995: 11). It can increase value without diminishing it somewhere else. In addition, knowledge goods have extensive externalities in which their benefits extends well beyond those who first put them forward while it can be difficult to exclude other potential users of knowledge through intellectual property rights. Hence social return on investment in knowledge and its generation can be multiplied through its diffusion.

Tenth, regarding systems of creation, production, and distribution, Houghton and Sheehan (2000) write that the commonly held notion that a knowledge economy comprises only the service economy is misleading. They explain that information and knowledge adding value to basic manufacturing of products and services are becoming increasingly integrated into complex chains of creation, production, and distribution. There is rather an essential impact of the knowledge economy and innovation on the value-chain of a commodity's production, construction, energy, distribution and other industries (Houghton, Pappas and Sheehan, 1999).

Eleventh, Houghton and Sheehan (2000) write that one of the features of the emerging knowledge economy is increasing evidence that the nations of the world are polarizing, rather than converging,

in economic terms. Countries appear to be moving towards either pole, one of high incomes the other of relatively low incomes. This polarization of countries into different strata of economic activity and of living standards is becoming both pronounced and persistent (Sheehan and Tegart, 1998).

Twelfth, there is increasing inequality that can be observed at the international, national, regional, household and personal levels. In other words, the rich are getting richer, while the poor are getting poorer. Some economists suggest that the increasing return from network economies and learning economies characterizes the knowledge economies. Others contend that there is an expansion of the knowledge-driven economy leading to a proliferation and an increase of materials, firms, and activities at all levels and all periods. This view suggests that there is much smaller opportunity for one to enjoy continuing control of markets (Houghton and Sheehan, 2000; Arthur, 1996: 100-109; Kay, in DTI, 1999; OECD, 1997).

From the differences above, we can summarize the key features of the knowledge economy and its players as follows (Brinkley, 2006: 13):

- The knowledge economy represents a “*soft discontinuity*” from the past through the rising essence of knowledge as a factor of production. It is important to note that the knowledge economy is not a completely “*new*” economy requiring a new set of economic laws;
- The knowledge economy is represented not only in the knowledge-intensive industries or service industries, but also in all sectors of the economy;
- The knowledge economy has a high and growing intensity of ICT usage by well-educated and skilled workers;
- A growing share of GDP (Gross Domestic Product) is devoted to producing intangible knowledge, relative to that of physical capital;
- The knowledge economy consists of softer innovations such as organizational and presentational innovations;
- The development of knowledge-based organizations requires them to handle, store, and share information through knowledge management practices.

2.1.4 Economic Colonization in KBE

As I mentioned in the eleventh and twelfth points of the section above, it appears that the knowledge-based economy could have negative impacts on developing and underdeveloped countries (Sheehan and Tegart, 1998; Houghton, and Sheehan, 2000; Arthur, 1996: 100-109; Kay, in DTI, 1999; OECD, 1997).

Many scholars in development studies argue that globalization and the knowledge-based economy is the way powerful western countries are to retain and increase their economic and political power, and many have called globalization the new form of economic colonization. As evidenced throughout the world, economically powerful countries often exploit underdeveloped and developing countries through accessing their resources and low-cost labour to further accumulate wealth. International financial institutions such as the International Monetary Fund (IMF) and the World Bank, along with European and U.S. policy makers, have preached “market fundamentalism” to the Third World – elimination of trade barriers, subsidies for local products, and protective regulations for products and services. Economically well-off countries have allowed their multinationals to capitalize market opportunities in targeted developing countries accommodating market fundamentalism, while protecting their domestic economic sectors (Petras, 2002).

To maintain their exploitation of resources and low-skilled/low-cost labour, multinational corporations do not transfer technology and skill to their host countries. Thus, it is impossible for underdeveloped and developing countries to be equal partners and to become competitively developed.

Several researchers throughout the world found that this foreign capital penetration exacerbates income inequality between rich and poor (Alderson and Nielsen 1999; Beer 1999; Bornschier and Ballmer-Cao 1979; Bornschier and Chase-Dunn 1985; Bornschier, Chase-Dunn, and Robinson 1978; Evans and Timberlake 1980). The argument here is four-fold. First, reliance on foreign investment distorts the class structure of the host country by generating a small, highly paid class of elites to manage these investments and expand the tertiary and informal sectors of the economy (Evans and Timberlake 1980; Kentor 1981; Timberlake and Kentor 1983). In the meantime, the majority of the employment generated by these investments is likely to be in low-wage jobs. Second, profits from these investments are repatriated, rather than reinvested in the host country, inhibiting domestic

capital formation (Bornschiefer 1980). Third, foreign capital penetration tends to switch land and property ownership from domestic to foreign entities (Furtado 1970). Finally, host countries are likely to create political and economic climates favourable to foreign capital that inhibit domestic labour from obtaining favourable wages and better working conditions (London and Robinson, 1989, cited in Kentor, 2001).

From the “divergence” perspective of Cook and Kirkpatrick (1997), the experience of low-income economies, particularly in sub-Saharan Africa, provides evidence that globalization leads to the widening of existing international disparities and a further marginalization of the majority of developing countries’ role in the world economy.

In addition, low income countries have faced a change in political economy and challenge due to the behaviour and structure of multinational corporations that underline the globalization of investment and trade flow. A major change of organization in host countries has been the shift in industrial organization from Fordist mass production to the global, flexible specialization paradigm. These changes have, in turn, been related to the increased importance of knowledge-based inputs to production and intra-firm organization, relative to labour cost that has been the key to competitiveness of lower-income economies (Cook and Kirkpatrick, 1997).

2.1.5 Clusters and Networks in KBE

In research into the knowledge-based economy, the concept and practices of *clusters* and *networks* have received continuous attention in recent years, not only as a tool of regional development, but also as instruments enhancing knowledge creation, dissemination and transfer through the knowledge infrastructure of a region and the interaction of different players (including firms) within an industrial cluster (Cantwell, in DTI, 1999; Devol, 1999: 9). Clusters are, therefore, often regarded as geographically condensed forms of economic cooperation and knowledge exchange (Steiner, 2004).

Much interest in the concept of clustering was sparked by the work of Michael Porter of the Harvard Business School (1990). Bergman and Feser (1999) explain that most cluster studies use Porter’s work as a framework for cluster analysis. Michael Porter (1998) defines clusters as “concentrations of interconnected companies and institutions in a particular field...[which] represent a kind of new

spatial organizational form in between arm's length markets on the one hand and hierarchies, or vertical integration, on the other. A cluster, then, is a new way of organizing the value-chain... A cluster of independent and informally linked companies and institutions represents a robust organizational form that offers advantages in efficiency, effectiveness, and flexibility" (Porter, 1998: 78-79). While the Department of Trade and Industry (DTI), U.K. (1998: 22) defines the cluster as "...a concentration of competing, collaborating and interdependent companies and institutions which are connected by a system of market and non-market links", Scottish Enterprise (1998) defines clusters as "...customers, suppliers, competitors and other supporting institutions such as universities, colleges, research bodies, financial institutions and the utilities."

The depth and breadth of clustering have increased as the market competition and economies have evolved in complexity. Globalization, together with rising knowledge intensity, has greatly supported the role of clusters in competitiveness (Porter, 1998a: 8). Porter introduces a concept of clusters because he feels that *sustained industrial growth* has hardly ever been built on basic inherited factors (land, location, natural resources, labour and local population size), as traditional economic theory maintains, and abundance of such factors may actually not deliver competitive advantage (The Executive Fast Track, 2007).

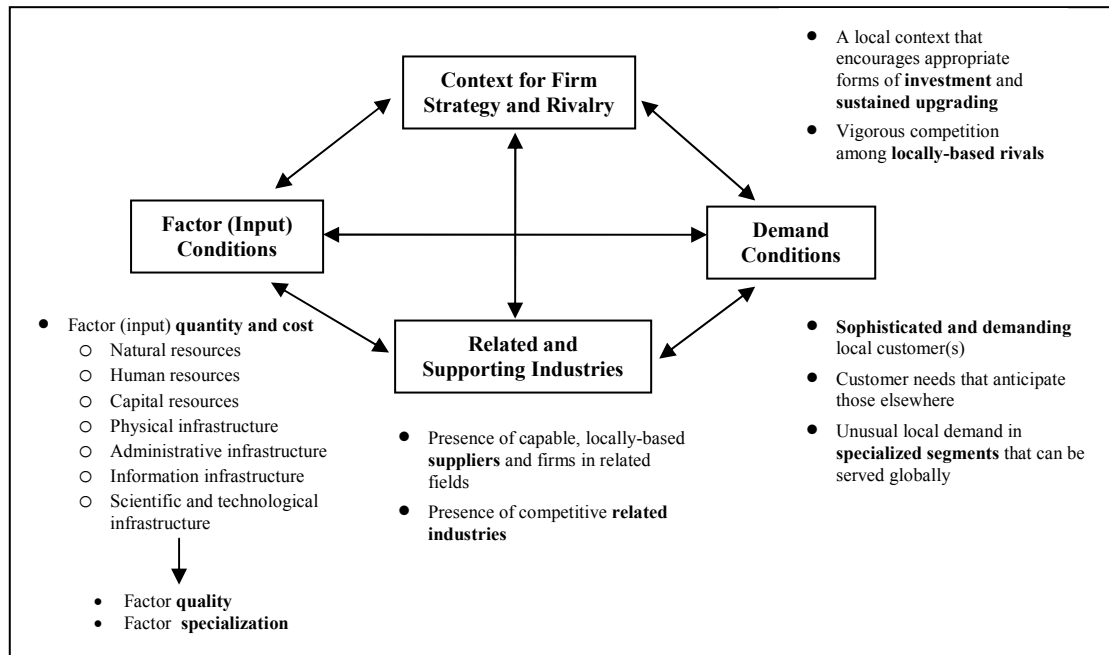
- **The birth of a cluster**

Clusters emerged through various means. In many cases, pioneering companies/institutions spin off other companies, or employees leave the pioneering companies to establish other firms in the same locality. For example, the birth of Silicon Valley is associated with the departure of eight disappointed employees from Shockley Semiconductor Laboratories in Mountain View California to establish Fairchild Semiconductor. In some other cases, public sector investment and public research laboratories have spawned clusters. For example, the US National Institutes of Health (NIH) in Maryland and their laboratories sparked the emergence of the biomedical cluster. Sometimes unexpected and precipitating events or historical events or circumstances cause cluster to rise. The Fiat tractor factory in Modena in the 1950s, for example, resulted in a local economy of small producers in the mechanical sector (Andriani et al., 2005: 9).

The facilitative conditions that improve the opportunities of cluster formation are a specialized labour force, a technological or market opportunity; and ready access to customers and market channels.

- **Clusters and competitive advantage**

It is widely recognized that most cluster studies use Porter's works and Porter's model of national competitiveness – the so-called “*Diamond Model*”- as a starting point for cluster analysis (Bergman and Faser, 1999) (see Figure 1).



Source: Porter, 1998a: 12

Figure 1: Diamond model, sources of locational competitive advantage

The *Diamond Model* (Figure 1) brings about competitive advantage in three dimensions. *First*, companies can operate with a higher level of efficiency, drawing on more specialized assets and suppliers with shorter reaction times than they could in isolation. *Second*, companies and research institutions can achieve higher levels of innovation and knowledge sharing. Knowledge spillovers and close interaction with customers and other companies create more new ideas and provide pressure to innovate, while the cluster environment lowers the cost of experimenting. *Third*, the level of business formation tends to be higher in clusters. Start-ups are more reliant on external suppliers and partners, all of which they find in a cluster. Clusters also reduce the cost of failure, as entrepreneurs can fall back on local employment opportunities in many other companies within the same field. (Ketels, 2003: 6-7).

The evolution of the cluster concept leads to determination of the role of private sector, government, trade associations, and educational or research institutions (Ketels, 2003b). It builds a new model of

collaboration between government, private sector, universities, and research institutions. The new/adapted roles of each player in a cluster-based economic development are as follows:

1) Government

Ketels (2003) applied Porter's Diamond Model to clarify the role of government in cluster-based economic development. He explained the four interrelating and influential roles of government in competitiveness:

Roles in factor (input) conditions: to create specialized education and training programmes; to establish local university research efforts enhancing cluster-related technologies; to support cluster-specific information gathering and compilation; and to improve specialized transportation, communications, and other infrastructure required by such clusters. **Roles in context for firm strategy and rivalry:** to eliminate barriers to local competition; to focus on efforts to attract foreign investment around clusters; to focus on export promotion around clusters; and to organize relevant government departments around clusters. **Roles in demand conditions:** to create pro-innovation, regulatory standards encouraging demand conditions (i.e. reduce regulatory uncertainty, stimulate early adoption of regulation, and encourage innovation or new products and processes); to sponsor independent testing, product certification, and rating services for a cluster's products and services; and to act as a sophisticated buyer of the cluster's products/services. **Roles in related and supporting industries:** to sponsor forums to bring together cluster participants; to attract suppliers and service providers from other locations; and to establish cluster-oriented free trade zones, industrial parks, or supplier parks.

In order to succeed in cluster-based development, Ketels (2003) suggested the important role of government at each level. **Federal:** the government should set the context through macroeconomic policy and microeconomic regulations, upgrade business environment conditions under national control, and enable regional competitiveness efforts. **State:** the government should initiate and facilitate state and cluster competitiveness efforts, upgrade business environment conditions under state control, and support local competitiveness efforts; **Local:** the government should participate in regional and cluster competitiveness efforts, and upgrade business environment conditions under local control.

2) Private sector

Ketel (2003) analyzed the role of private sector influences on upgrading the cluster by using the four interrelated influences of the “*Diamond Model*” as follows:

Roles in factor (input) conditions: to jointly develop specialized curricula of vocational, technical, college and university education to serve the relevance, to sponsor specialized university research centres, to collect cluster information through trade associations and to maintain close liaison with infrastructure providers to address clusters’ needs (i.e., data communications, logistics); and to develop courses for managers on regulatory, quality, and managerial issues. **Roles in context for firm’s strategy and rivalry:** to support the market jointly through trade fairs and delegations, collaborate with government export promotion efforts, and to create directories of cluster participants. **Roles in demand conditions:** to work with government to streamline regulations and modify them to encourage innovation, and to establish local testing and standards organizations. **Roles in related and supporting industries:** to establish a cluster-based trade association, to encourage the formation of local suppliers, and to attract local investments through new suppliers, individuals and collective efforts.

3) Universities and research organizations

In cluster-based economic development, Ketels (2003) analyzed the role of universities by stating that universities and non-profit research institutions need to actively cooperate with co-located companies and other institutions to pursue their role as a part of cluster and an engine of the regional growth/business development.

The key roles for universities are to generate knowledge/innovation, to transfer knowledge/innovation to firms and their workforce, to develop a workforce that is competent in relevant skills, to attract new investments due to positive externalities, and to facilitate the players/enhancers of competitiveness. Thus, universities that become more engaged in the development of their regional business environments could lead to direct benefits to the cluster. In addition, universities attract faculty members and students providing positive impact on research, education and workforce of the region.

2.2 Universities and their roles in KBE

From the literature on the knowledge-based economy, the economic competitiveness of a country does not necessarily depend on vast natural resources, a large population and physical capital, although having these assets and resources is certainly beneficial. It is the quality of human capital and the ability of a nation to generate innovations and effectively exploit new ideas and inventions on the global market that are now critical for a country's economic growth.

What then is the strategic role that universities can play in the knowledge era?

Yam (2000) suggested that universities need to respond to the challenges of the knowledge era by strengthening their roles in the areas of knowledge dissemination, creation, and application. This has implications for undergraduate education, postgraduate study/research, and continuing education/training.

First, in undergraduate education, the university has to expose students to a broader range of skills, in order to prepare them for workplaces that need a multi-disciplinary and systematic approach in problem-solving. For postgraduate education and research, the university aims to make a greater impact on economy and society through new ideas, knowledge and innovation. It is in postgraduate education that the role of university in knowledge creation becomes very essential.

Second, in term of universities' research, universities must carry out research with high impact in different sectors and levels of development. The university constitutes a significant resource of new ideas and inventions with the potential for commercial applications. It is also collaborating with national research institutes and centres, and strengthening links with industry through joint projects in high technology cutting-edge research. With the move to a knowledge economy, universities are now part of the whole value generating chain of the economy. The time has now come to strengthen the role of the universities as engines of innovation and entrepreneurship. In particular, universities with substantial science and technology based teaching and research staff and students constitute an important source of potential technological entrepreneurs, or 'technopreneurs', as well as science and technology ideas and research (Yam, 2000). An indicator of the success of a university is its capability to generate high technology spin-off companies and to nurture graduates who can create their own jobs, and not merely only fill job vacancies created by foreign investment.

Third, the other key area of universities' activities, along with research and producing graduates, is that of continuing education and training. Yam (2000) suggests that a university will find it increasingly difficult to sustain its influence unless it continues to play an essential role in lives of its graduates, constituents and communities. A university should reach out to alumni and constituents (i.e. the business community, local professionals, government) not simply for fund-raising purposes, but also so that it can serve as part of the continuous development of the intellectual capital of its alumni and constituents. Only through playing their role in the continuing education of their graduates and constituents will make universities stay relevant. This will require the universities to re-think about their relationship with their community of current students, alumni and other constituents. The relationship may have to shift from an intensive period of interaction to one of life-long interaction, comprising durations of encounter beyond the undergraduate or postgraduate phases. Universities may have to think of ways to draw each graduating class and constituents back to the universities for continuing education. The reciprocal benefits of continuing education for the universities will be that many of these graduates and constituents will return for refresher courses with more maturity and full of new ideas which can in turn spark off new ideas for professors. While technology can be of assistance in this regard, for example in facilitating distance education, many issues such as funding and the effective form of continuing education have yet to be worked out. There is a wide scope to learn how different countries are rising to the challenges.

In reality, a university fulfils at least two essential roles in the knowledge-based economy – the performance of research and the training of highly qualified personnel. The university thus acts both as a primary source of “*knowledge workers*,” as well as a producer of the KBE’s key factor of production– knowledge itself (Wolfe, 2005). Changes in environments and in the essence of the innovation system have placed new demands and stresses on to a university in the performance of its key roles.

Increasing demands on universities to support the innovation process are partly a consequence of innovation patterns that have limited the ability of private firms to support basic research. Under competitive pressure to introduce new products, processes and services at high speed, many large corporations have restructured their research and development operations to link research programs more tightly with product development processes. At the same time, the globalization of research and development and more widespread sharing of knowledge among researchers and business in different countries do not appear to have diminished the importance of a strong domestic knowledge

base, or the role of universities and government in facilitating its development (Wolfe, 2003). Under increasing pressure, universities must expand their traditionally dominant role in conducting basic research to supplement applied research activities, frequently based on university-industry partnerships. The changes impacting on the university system are characterized by three trends: 1) the stronger linkage of government funding and economic policy to academic research; 2) the development of more long term relationships between firms and academic researchers; and 3) the increasing direct participation of universities in commercializing research (Etkowitz and Webster, 1998). This means that universities are now expected to generate more applied knowledge of greater relevance to industry, to diffuse knowledge, and to provide technical support to industry.

Wolfe (2005) suggests that the relationship between public-funded research and innovation process is far more complex than that assumed by many recent public policy discussions regarding the role of the university in commercializing scientific research. A more accurate understanding of this role requires a sophisticated framework for analyzing the character of the institutional and interpersonal linkage between universities and firms and how those linkages contribute to knowledge transfer between the two.

Pavitt (1991) stresses scientific and technological knowledge often remains tacit. Other scholars in the tradition of evolutionary economics describe knowledge as dynamic, often unarticulated, and claim that the firm must invest substantial resources to capture and employ it. However, Pavitt (*ibid*) argues that inherent in the traditional rationale for public support of basic research is the danger of confusing the notion of science as a public good (i.e. codified, published, easily reproducible) with science as a free good (i.e. costless to apply as technology). He builds on Nathan Rosenberg's claim that, to assimilate and benefit from external research, firms have to develop a considerable capacity for research themselves (Rosenberg, 1990). Pavitt stresses that knowledge transfer is mainly person-embodied and that policies that attempt to direct basic research towards scientific goals or targets ignore the considerable indirect benefits across a broad range of scientific fields that result from training and unplanned discoveries. From the perspective of the firm, Cohen and Levinthal (1990) argue that the process of knowledge transfer from universities and research institutes is strongly conditioned by the capabilities of firms. Firms need to build an internal knowledge base and research capacity to effectively capture and deploy knowledge acquired from external sources. The ability to exploit external knowledge is a critical component of a firm's innovation capabilities. The overlap

between the firm's knowledge base and external research allows the firm to recognize potentially useful outside knowledge and use it to reconfigure and augment its existing knowledge base.

An implication of this argument is that firms require a strong contingent of highly qualified research scientists and engineers as a prerequisite to the ability to absorb and assess scientific results, most frequently recruited from institutions of higher education. The members of this scientific and engineering labour force bring with them not only the knowledge base and research skills acquired in their university training, but often, more importantly, a network of academic contacts acquired during their university training. This underlines Pavitt's point that the most important source of knowledge transfer is person-embodied.

The findings of the Carnegie Mellon Survey reinforce the perspective that a key aspect of the process of knowledge transfer from universities and research institutes is through personal connections and the knowledge being transferred is thus "*tacit*" and "*embodied*": to deploy university – generated knowledge in a commercial setting, firms need to capture both its tacit, as well as its more explicit, or codified, component (Wolfe, 2005).

Another study carried out by Wendy Faulkner and Jacqueline Senker (1995), cited in Wolfe's paper, attempts to develop a better understanding of the knowledge flows from academia to industry. The findings differ slightly by industry, they do, however, conclude that partnering with universities contributes to firms' innovation through an exchange of tacit knowledge, and that the channels for communication are often informal. The informal linkages are both a precursor and successor to formal linkages and many useful exchanges of research materials or access to equipment take place through non-contractual barter arrangements. The flexibility inherent in such arrangements promotes the goodwill between partners that supports more formal linkages (Faulkner and Senker, 1995).

Furthermore, Wolfe's paper indicates that proximity to the source of the research is important in influencing the success with which knowledge generated in the research laboratory is transferred to firms for commercial exploitation, or process innovations are adopted and diffused across developers and users. The most frequently cited explanation for this proximity effect is the need to gain access to tacit knowledge, or at least knowledge that is not yet codified. Conversely, the role of proximity declines when useful knowledge is readily available in more codified forms that can easily be

transmitted and accessed across broad distances (Feldman, 2000; Adams, 2001; Arudel and Geuna, 2001).

The proximity effect of knowledge transfer provides a strong clue as to why the university is increasingly seen as an essential element in the process of regional economic development and for stimulating the formation of clusters, especially in knowledge-intensive industries. A critical issue involves the question of which of the university's central roles in the knowledge-based economy – the performance of scientific research or training of highly qualified personnel – exerts the dominant influence on the process of regional economic development and cluster formation.

In addition, Wolfe's paper discusses the recent research on the growth and development of three major information and communications technology (ICT) clusters in Ontario (Ottawa, Toronto and Waterloo), documenting the important contribution made by the research infrastructure, both public research laboratories and post-secondary educational institutions, in all three communities (Wolfe, 2002). The case study of the three clusters suggests that the presence of universities and research institutes attracted inward investment, as leading anchor firms became interested in tapping into the knowledge advantage of the local community and the talent pool that firms could take advantage of. In this respect, universities also act as part of the network linking players in the local cluster to the global pipeline that is critical to the knowledge flows in the cluster.

For Thailand's higher educational institutions, the government does not only expect to see Thai universities producing graduates efficiently, but also graduates with employability and value-added skills to effectively serve as a productive workforce. In addition, graduates are expected and trained to be ethical, socially responsible and have integrity. Thailand's economy needs manpower with diversified talents and different levels of skills to bring Thai social and economic development to new heights. Competent human resources are needed to serve as leaders of society to propel the Thai economy to be more competitive on global and regional scales. Critical mass and competent leaders must be supplied into different sectors of Thai society to develop the public service, local communities and industries. Human resource development is a priority in national blueprints and an important arena in making the Thai economy competitive in the global arena and to achieve competitive advantages against other economies. The most important expectation for Thailand's higher education is to be able to contribute toward the creation of social equality and justice and to bring about better quality of life for people.

In order to adjust Thai universities' roles to serve Thai social and economic development more effectively and efficiently, Thai universities have to establish closer relationships and networks with communities, business and industries whilst integrating university functions as a component of the industrial/production process of the Thai economy (Chandarasorn, 2002). The paper presented by the Director-General of the Commission for Higher Education in 2002 suggested that Thai universities used to operate within a closed boundary; this must be opened to be accessible for all sectors of economy. Information required for social and economic development from outside must be interchanged to make higher education more susceptible to global changes. In the age of the knowledge-based economy where economic development is rather dynamic, Thai curricula must be redesigned and adapted to changes and to the needs of the private sector and communities. Universities' teaching and learning must meet the requirements of labour markets and communities so as to avoid educational and resource wastage. Universities must produce quality graduates who will become the backbone of the country's development process. Universities are where knowledge has been gathered and served as depository of world heritage; in addition, they are an original source generating new medicine, new inventions, and new theories regulating the world social and economic order that are beneficial to the well-being of all mankind. Academic institutions are also the mainstays of solutions to social and economic problems and serve as society's intellectual bank. Universities must be financially secured and should not take any advantage of their clients or society but rather act as donors, dedicating their service solely to social prosperity. Institutions must be immune to any political interference and must not serve as proxies of any political players (Chandarasorn, 2002).

Furthermore, Chandarasorn (2002) asserts that universities should adopt strategies for dealing with academic cooperation with foreign countries and reveal information of their collaboration with any particular foreign institution which may benefit other universities. However, restructuring of organization with dispersed functions is required to establish networks of universities, students, communities, business and industrial operators, and in some cases foreign institutions.

2.3 Universities' functions within an innovation system

As mentioned in the previous sections, knowledge and innovation have become increasingly critical in the knowledge-based economy. Universities throughout the countries of the OECD thus pursue the combined functions of education and research to better serve industrial demands. This joint

production of trained personnel and advanced research are complementary in their roles and objectives, while combining these functions is more effective than pursuing either function alone (Mowery and Rosenberg, 1989). The transition of trained personnel into industrial and other occupations is a powerful mechanism for the diffusion of scientific research, while realizing demands from prospective employers for “relevance” in curriculum, training and research can strengthen linkages between the academic research agenda and the needs of industry.

The outputs of university research have come in different forms, varying over time and across industries. They include, among others, scientific and technological information, equipment, instrumentation, skills/human capital, networks of scientific and technological capabilities, and prototypes for new products and processes (Rosenberg, 1994, 1999; Cohen *et al.*, 1998; Mowery and Steinmueller, 1992; Nelson, 1982).

As universities are often cited as a critical institutional actors in national innovation systems (Nelson, 1993), most of the literature on “national innovation systems¹” defines them as the institutions and actors that are critical for the creation, development, and diffusion of innovations. The literature on national innovation systems emphasizes the importance of strong linkages among different institutions/players in improving national innovative and competitive performance, and this emphasis applies in particular to universities within national innovation systems (Mowery and Sampat, 2004).

For this section, I employ four frameworks, consisting of “Linear Model”, “Contrasting Norm”, “Mode 2”, and “Triple Helix”, to explain the significance of universities linkages.

¹ Although a national innovation system is difficult to precisely define, earlier works on the Japanese and US national innovation systems (Freeman, 1987; Nelson, 1990, 1992, 1993) have defined them as the network of public and private institutions within an economy that fund and perform R&D, translate the results of R&D into commercial innovations, and affect the diffusion of new technologies. More concretely, a national innovation system includes the public agencies that support and/or perform R&D; universities which may perform research and play an important role in the training of scientists and engineers; the firms within an economy that invest in R&D and in the application of new technologies; any public programmes intended to support technology adoption; and the array of laws and regulations that define intellectual property rights.

- **Linear Model**

An important framework for analysing the role of academic research within national innovation systems and economies is the “*linear model*” of innovation, associated with Vannevar Bush and his famous “blueprint” for the U.S. post-1945 R&D system, ‘Science: The Endless Frontier’. Bush argued that expanded public funding for basic research within U.S. universities is a critical contributor to economic growth, and universities are the most appropriate institutional locus for basic research. This “linear model” of the innovation process asserted that funding of basic research is both necessary and sufficient to promote innovation. Bush’s argument anticipated parts of the “market failure” rationale for the funding of basic academic research subsequently developed by Nelson (1959) and Arrow (1962). This portrayal of the innovation process has been widely criticized (see Kline and Rosenberg, 1986, for one such rebuttal of the linear model). Many U.S. policymakers during the 1970s and 1980s cited the Japanese economy as evidence that basic research may not be necessary *or* sufficient for a nation to improve its innovative performance (Mowery and Sampat, 2004).

- **Contrasting Norms**

Yet another view of the role of universities’ research focuses on the contrasting “*norms*” of academic and industrial research. Merely contrasting the “fundamental” research activities of academics with the applied research of industrial scientists and engineers obscures as much as it illuminates. After all, there are abundant examples of university researchers who make important contributions to technology development, as well as numerous cases of important basic research conducted in industrial laboratories.

Paul David and colleagues (Dasgupta and David, 1987; David, Foray, and Steinmueller, 1999), however, argue that the norms of academic research differ significantly from those observed within industry. For academic researchers, professional recognition and advancement depend crucially on being first to disclose and publish their research result. Prompt disclosure of results and the methodology used to achieve them is central to academic research. Industrial innovation, by contrast, relies more heavily on secrecy and limitations to the disclosure of research results. The significance of these “cultural differences” for the conduct and dissemination of research may assume greater

significance in the face of closer linkages between university and industrial researchers (Mowery and Sampat, 2004).

These contrasts, however, could be overstated, as David et al. (1999) acknowledge. The history of science reveals repeated examples of fierce competitions (“discovery races”) between teams of researchers in a given field that systematically seek to mislead one another through the disclosure of false information. Recent research by Henderson and colleagues (Henderson, Pisano, and Orsenigo, 1999; Henderson and Cockburn, 1998) on the pharmaceutical industry’s R&D highlights the increased emphasis on a number of large pharmaceutical firms’ publications written by industrial researchers as a means of improving their basic science capabilities. Nevertheless, the potential clashes of disclosure norms between academia and industry remains significant (Mowery and Sampat, 2004).

- **Mode 2**

Another conceptual framework that has been applied recently to descriptions of the role of academic research in “post-modern” industrial societies is the “*Mode 2*” concept of research, identified by Michael Gibbons and colleagues (Gibbons et al., 1994). “Mode 2” research is associated with a more interdisciplinary, pluralistic, “networked” innovation system (Mowery and Sampat, 2004).

It is contrasted with the traditional “*Mode 1*” production of knowledge that is generated by scientists of a particular field, while Mode 2 is characterized as the production of knowledge for multi-disciplinary application (i.e. bioengineering) (Huff, 2000: 288).

Gibbons and other scholars argued that the growth of “Mode 2” research reflects the increased scale and diversity of knowledge inputs required for scientific research. Increased diversity in inputs, in this view, is associated with greater inter-institutional collaboration and inter-disciplinary research. Because “Mode 2” involves the interaction of many communities of researchers and other actors within any given research area, purely academic research norms may prove less influential in such areas of applied research as biomedical research (Mowery and Sampat, 2004).

The “Mode 2” framework is consistent with characteristics of modern innovation systems, notably the increased inter-institutional collaboration that has been remarked upon by numerous scholars.

But this framework's claims that the sources of knowledge within modern innovation systems have become more diverse do not necessarily imply a decline in the role of universities as fundamental research centres. Several studies (Godin and Gingras, 2000; Hicks and Hamilton, 1999; see below for further discussion) support the "Mode 2" assertion that cross-institutional/inter-disciplinary collaboration and diversification in knowledge sources have grown, but indicate no such decline in the demand for fundamental research (Mowery and Sampat, 2004).

- **Triple Helix**

The "*Triple Helix*", popularized by Etzkowitz and Leytesdorff (1997), is another conceptual framework for analyzing the changing position of universities within national innovation systems that emphasizes the increased interaction among various institutional actors in industrial economies' innovation systems, specifically universities, industry and government. There are tri-lateral networks among three spheres/institutions while each sphere takes role of the other as they become hybrid organizations. Etzkowitz et al. (1998, cited in Mowery, D. and Sampat, B., 2004) further assets that:

"In addition to linkages among institutional spheres, each sphere takes the role of the other. Thus, universities assume entrepreneurial tasks such as marketing knowledge and creating companies even as firms take on an academic dimension, sharing knowledge among each other and training at ever-higher skill levels. (p. 6)."

The "Triple Helix" is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. The first dimension of the Triple Helix model is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of economic development mission by universities. The second is the influence of one helix upon another. An example is the role of the government in instituting an indirect industrial policy through sponsoring research and technology transfer activities throughout broader range of universities, resulting in the emergence of an academic technology transfer profession. The third dimension is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices for the purpose of coordination and generation of new ideas and formats for high-tech development (Etzkowitz, 2002).

The Triple Helix denotes the university-industry-government relationship as one of relative equal, interdependent, institutional sphere which overlap and take the role of one another. Bilateral relations between government and university, academia and industry and government and industry have expanded in to triadic relationships among the spheres. Academic-industry-government relations are emerging from different institutional starting points in various parts of the world, but for the common purpose of stimulating knowledge- based economic development (Ibid, 2002).

The “*Triple Helix*” scholarship devotes less attention to the “transformations” in industry and government that are asserted to complement those in universities. The model emphasizes more on the “industrial” role of universities, although it overstates the extent to which these “industrial” activities occur throughout universities, rather than in particular fields of research. The “Triple Helix” has yet to yield major empirical or research advancement, while its value as a guide for future empirical research appears to be rather limited (Mowery and Sampat, 2004).

Summary:

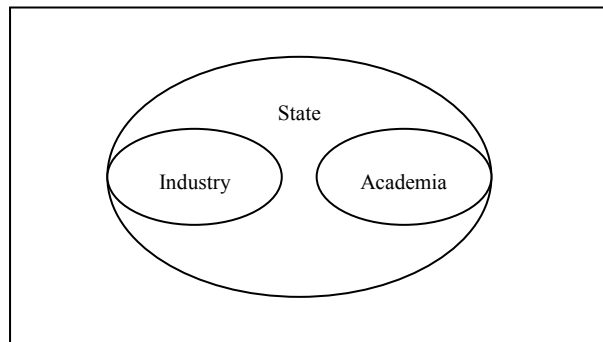
The “national systems of innovation,” “Mode 2,” and “Triple Helix” frameworks for conceptualizing the role of the research university within the innovation processes of knowledge-based economies emphasize the importance of strong linkages between universities and other institutional actors in economies. Both “Mode 2” and the “Triple Helix” argue that interactions between universities and industry, in particular, have increased in both practice and demand. According to the “Triple Helix” framework, increased interactions are associated with transformation within the internal culture and norms of universities (Mowery and Sampat, 2004; Lundvall, 1988 and 1992; Nelson, 1993; Edqvist, 1997; Gibbons *et al.*, 1994; Nowotny *et al.*, 2001; Etzkowitz and Leydesdorff, 1997, 2000; Leydesdorff and Etzkowitz, 1998).

2.4 Triple Helix of University-Industry-Government (U-I-G) relations in KBE

2.4.1 The Evolution of Triple Helix in KBE

Etzkowitz, H. and Leydesdorff, L. (2000: 111) described the evolution of innovation systems, and the current conflicts over which path should be taken in university-industry relations are reflected in the varying institutional arrangements of university-industry-government relations. *First*, one can distinguish a specific historical situation which may be labelled “Triple Helix I/ Etatistic Model”. In

this configuration the nation state encompasses academia and industry and directs the relations between industry and academia (Figure 2).



Source: Etzkowitz and Leydesdorff, 2000

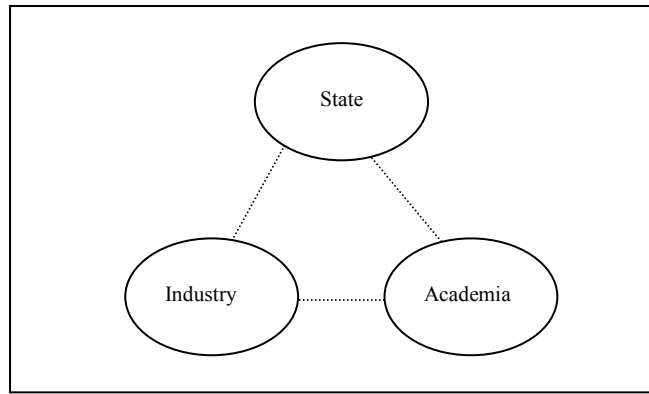
Figure 2: An Etatistic model of University-Industry-Government relations

A strong version of this model could be found in the former Soviet Union, and some eastern European countries under “existing socialism,” and weak versions were formulated in the policies of many Latin American countries and to some extent in European countries such as Norway in the era when state-owned industries were predominant. In these countries, government was the dominant institutional sphere. Industry and the university were basically part of the state. When relationships were organized among the institutional spheres, government played the coordination role.

A model of such a relationship in Latin America was provided by the Argentinean physicist, Jorge Sabato². He proposed a top-down model of development, with government directing/coordinating industry and academia in their “intra” and “inter” relations with one another that moves beyond the more traditional model of government coordinating each sphere separately to promote technology development (Dos Santos and Fracasso, 2000).

The *Second* relationship model (Figure 3 labelled as Triple Helix II/ Laissez-Faire Model) consists of separated institutional spheres with strong boundaries dividing them and highly circumscribed relations among the spheres, exemplified in Sweden by the noted *Research 2000 Report* (MacLane 1996; cf. GUIRR 1998; Etzkowitz and Leydesdorff, 2003: 111).

² Sabato and Botana (1968) developed a single model to describe the importance of enterprise-university relationship for economic development, which became known as the “Sabato Triangle.”



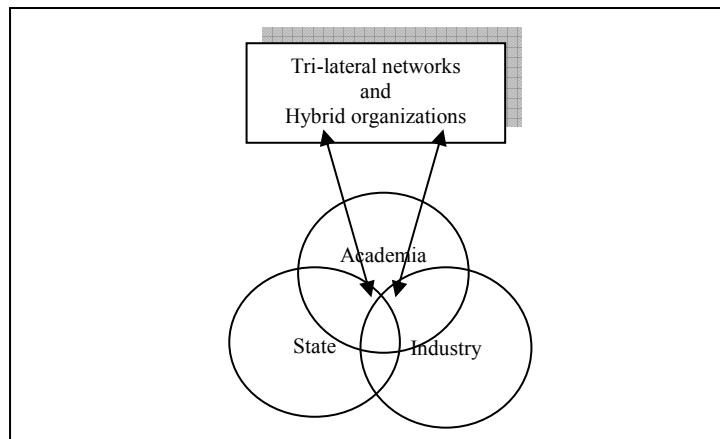
Source: Etzkowitz and Leydesdorff, 2003

Figure 3: A "Laissez-Faire" model of University-Industry-Government relations

The Laissez-Faire Triple Helix of separated institutional spheres is one in which individuals are expected to act competitively rather than cooperatively in their relations with one another. Strict separation leads to narrow roles for institutions, strong boundaries, and standards for justifying interaction among the institutional spheres. In reality, the spheres often have closer relationships than that in the Laissez-Faire model of government, industry, and academia operating in their own areas without close relationship. Etzkowitz (2000) argues that, in this Laissez-Faire model, the university is a provider of basic research and trained persons. Its role in connection with industry is to supply knowledge, mainly in the form of publications and graduates, who bring tacit knowledge with them to their new jobs. It depends upon industry to find and apply useful knowledge from the universities without much assistance and coordination (Etzkowitz, 2003: 305).

The differences between the above two versions of the Triple Helix arrangements currently generate normative interest. Triple Helix I is largely viewed as a failed development model with too little room for “bottom up” initiatives, as innovation was discouraged rather than encouraged. Triple Helix II entails a Laissez-Faire policy, advocated as shock therapy to reduce the role of the state in Triple Helix I (Etzkowitz, and Leydesdorff, 2000: 112).

Third, Triple Helix III is generating a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces (Figure 4).



Source: Etzkowitz and Leydesdorff, 2000

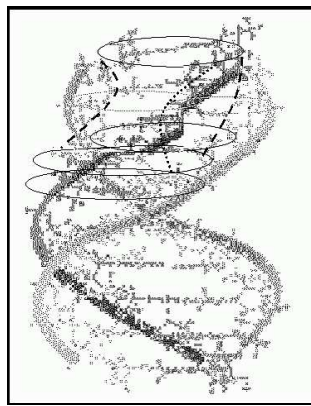
Figure 4: The Triple Helix model of University-Industry-Government relations

In one form or another, most countries and regions are presently attempting to achieve some form of the Triple Helix III. The common objective is to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, strategic alliances among firms and other players (large and small operating in different areas and with different levels of technology), government laboratories, and research collaboration. These arrangements are often encouraged by government through different instruments such as direct or indirect financial assistance, the Bayh-Dole Act in the U.S.A. transferring property right's ownership to university, new actors/foundations such as the National Research Council to promote innovation in Sweden (Etzkowitz and Leydesdorff, 2000: 112).

2.4.2 The Triple Helix model of innovation

Etzkowitz and Leydesdorff (2000) explain the typifications of “national system of innovation” (Lundvall, 1988; Nelson, 1993), “research systems in transition” (Cozzens *et al.* 1990; Ziman, 1994), Mode 2 (Gibbons *et al.* 1994) and “the post modern research system” (Rip and Meulen, 1996) as indicative of flux, reorganization, and the enhanced role of knowledge in the economy and society. In order to explain these observable reorganizations of university-industry-government relations, one needs to transform the sociological theories of institutional retention, recombinatorial innovation, and reflexive controls that can be expected to appreciate different sub-dynamics (Leydesdorff, 1997).

Etzkowitz and Zhou explain that knowledge capitalization has various sources in industry, universities and government institutes. When knowledge is transformed into capital, individuals from the originating organization become potential entrepreneurs and the enterprise's founders. The Triple Helix (III) in which each strand may relate to the other two can be expected to develop an overlay of communications, networks, and organizations among the helices (Etzkowitz and Leydesdorff, 2000). Figure 5 below reflects the spirally developing Triple Helix, a synthesis of evolution in the vertical axis and circulation in the horizontal.



Source: Etzkowitz and Leydesdorff, 2000

Figure 5: The Spirally Developing Triple Helix model of University-Industry-Government relations

Innovation begins to take on a new meaning as the spirals of the Triple Helix intertwine, while cooperation from a position of relative autonomy is to enhance each other's performance of their traditional roles (Etzkowitz and Leydesdorff, 1997 & 2002). The increased interaction, as relatively equal partnership, among university, industry, and government and the new development in innovation strategies and practices that arise from this cooperation are the core of the Triple Helix model of economic and social development.

The role of the university is increasingly controversial, especially as entrepreneurial formats emerge in academic venues of such 'public' and ivory tower' universities, and academic institutions with a traditional practical bent such as polytechnics, engineering, and agricultural schools. Topics discussed include organizational formats such as technology transfer offices, centres, research groups, incubators; technology parks; cooperative research schemes; patenting and intellectual property issues; the university's regional role; changing academic norms and values; faculty and student roles in firm formation; conflict of interest and obligation issues; entrepreneurial education;

co-production of research or external influence on direction of research; the privatization of the university; academicization of firm; and the development of new universities as an overlay on science parks (Etzkowitz and Zhou, 2006).

Etzkowitz and Zhou (2006) declare that entrepreneurial universities are expected to play a leading role in regional innovation and to encourage start-ups. Similarly, industry is expected to reorganize itself in a network mode to be more receptive to external inputs. Government is expected to develop programs cooperatively with the other actors to support enhancement of the universities, industry and the linkage between them. The three spheres are expected to act as a common subject and cooperatively implement an economic growth strategy. It seems a very coherent and ideal situation.

An entrepreneurial university serves the generative principle of university-industry- government interactions as a source of innovation. Ability to act as an independent entity is a necessary but not sufficient condition (Clark, 1998). The key elements of the entrepreneurial university model are: a research base with commercial potential, a tradition of generating start-ups, an entrepreneurial ethos on campus, policies for defining ownership of intellectual property, sharing profits and regulating conflicts of interest and participation in regional innovation strategy (Etzkowitz & Zhou, 2003).

Entrepreneurship has become part of the academic research ethos. The importation of strong commercial research norms from Germany, combined with a lack of resources to support research, created an impetus to entrepreneurship in U.S. universities in the mid-19th century (Jencks and Riesman, 1968).

Knowledge spillover from universities promotes regional development, through commercialization of research and provision of new firms, human resources and new ideas (Etzkowitz & Zhou, 2003). Sexenian's work (1994) asserts the importance of "knowledge externalities" on the economics of networks and clusters. The emphasis on knowledge reflects the declining relative importance of material input in various manufacturing industries, the increasing roles of service industries, and the increased similarity of costs everywhere.

In order to explain the continued essence of "knowledge spillovers" (Jaffe *et al.*, 1993; Audretsch and Feldman, 1996), most works invoke the concept of "tacit knowledge". As Audretsch puts it, "The propensity for innovative activity to cluster spatially will be the greatest in industries where

tacit knowledge plays an important role... it is tacit knowledge, as opposed to information, which can only be transmitted informally, and typically demands direct and repeated contacts” (Audretsch, 1998, p.23). In short, firms and actors within a network can benefit greatly through belonging to the related or complementary epistemic communities existing around the specific professional practices’ activities. Respected communities share both the explicit and the tacit elements of knowledge in forming their practices.

2.4.3 Experience of the Triple Helix in Various Countries

- **United States**

Under the cover of an ‘endless frontier’ ideology of government funding without strings attached, linkages appeared in fits and starts to overcome gaps among the institutional spheres that had been only temporarily elided during the Second World War. When blockages to interaction appeared, they were resolved through a political process that was given impetus by the industrial crisis that arose from increased international competition for the US industry in the 1960s and 1970s (Etzkowitz *et al.*, 2000: 317).

The 1980 Bayh–Dole Act gave ownership of intellectual property, arising from federally funded research, to the universities. Nevertheless, the outcome was also a balance between traditional professorial rights and the institutional interests of the university. In the universities at least, innovators, by tradition, and soon by law, were guaranteed at least 15% of the returns on their invention (Ibid: 318).

Under the law, universities were obligated to make an effort to commercialize these rights. Universities such as MIT with its commitment to supporting industry and regional growth of Route 128 and Stanford with its spirit of entrepreneurship supporting Silicon Valley, which had been anomalies within the US academic system, now became the models for other universities to emulate. Other schools such as Columbia, which previously viewed themselves as playing a policy and service role in supplying faculty members going to Washington to serve temporarily in government, now found themselves trying to establish new ties with industry, often in their local region (ibid: 318).

Etzkowitz *et al.* (2000:319)'s study found that universities gradually extended their activities into the technology transfer process, identifying and filling gaps in the technology 'push' process, establishing incubators to assist the formation of firms from campus research and facilitating venture capital arms to fill gaps in the availability of 'seed' funding. Government programmes, such as the Small Business Innovation Research (SBIR) Program, also increasingly played the role of 'public entrepreneur' in assisting the financing of new firms (Etzkowitz *et al.*, 2000).

In 1862, the Morrill Act assigned government owned land to a special class of universities to support the national development of agriculture. In 1980, the Bayh–Dole Act turned over intellectual property rights emanating from federally funded research to all universities as a virtual equivalent of a land grant. As the dividends in technology transfer and formation of new firms grows from the Bayh–Dole Act, it may eventually come to be as significant to US innovation and economic development as the Morrill Act (Etzkowitz *et al.*, 2000:319).

The situation in the US suggests a gradual transformation over time of the institutional character of the university sector, but it is also clear that these changes accelerate as a result of the qualitatively new dynamics of the knowledge society, such as trilateral networks which create their own institutional configuration and institutional space. Similar structural shifts can also be seen outside of the US, but limitations of space here do not allow similar stories of many others (Ibid: 319).

• **United Kingdom**

Etzkowitz *et al.* (2000: 319) argued that public funding for university research in the UK has become dependent on the perception of whether it will make a direct contribution to the economy. The reduction of research funding has forced public sector institutions, especially universities, to undertake activities that either attract industrial funding or generate income. Partly as a response to government policies (both Conservative and most recently Labour), universities have become involved in exchange activities such as licensing patents and establishing innovation centres. At the same time, changing relations between knowledge producer/user links through outsourcing, the arrival of trans-organizationally dependent technologies (such as bioinformatics), and the rapid growth of information sourcing have created the re-configuration of institutional relations. For universities, these have meant seeing a shift from a grant to an exchange economy in higher education. This phenomenon requires new institutional orders and modified academic regimes that govern and reward entrepreneurialism.

In 1985, UK universities were given the right and responsibility to exploit their intellectual property by securing property rights to ensure publicly funded work was transferred to the private holders. From the government's perspective, the devolution of rights from the state agency -British Technology Group (BTG)- to universities was intended to both help universities generate income for themselves and contribute to national wealth creation. The decentralization of technology transfer and the privatization of BTG represented a turning point in the evolution of the entrepreneurial university in the UK (Etzkowitz *et al.*, 2000:319).

A recently completed study of university spin-off firms (USOs) in the sectors of materials, scientific instruments and information technology came to divide spin-off firms into four distinct types (Webster and Rappert, 1997; Rappert and Webster, 1998; Rappert *et al.*, 1999). The *independent firm* (54% of the sample) is a firm which has broken away from the university, where the university's contact is relatively modest. The *hybrid firm* (17%) is a firm that is likely to be located within the university and dependent upon the University for a Degree of administrative and financial support. Intellectual property rights are shared with academic research groups, and the firm's staff occupies both academic and company positions simultaneously. Hybrids, however, seek the growth that will take them to full independent status (Ibid: 320).

The *shell firm* (21%) is sometimes, but not always, located within a wider university holding company. Such a firm is designed primarily to pull in research income for a university department. The founders see the establishing of a shell company as merely one mechanism among a range of industry liaison and contractual arrangements. Finally, the *virtual firm* (8%) brings together research staff from a number of academic sites across the UK to develop new embryonic product ideas, unlikely to be found within a single university department, for third parties to commercialize them in the market (Ibid: 320).

The growth of a USO reflects its role in relation to the parent university. Shell firms, which earn modest (though occasionally high) levels of income for university departments are likely to be less exposed to financial risk because of the buffer provided by the university. On the other hand, such firms may also have restricted growth patterns as centres for employment because of internally structural constraints associated with university's departmental procedures to which the shell firm is subject to.

This brief discussion of USO illustrates the process of ‘institutional formation’ noted above. These new spin-off organizations often acquire distinctive linkages with university, especially in the areas of research and resource sharing. Notwithstanding this, however, it is still likely to be the case that whatever the cultural setting — whether in Germany or the UK, for example — the wider processes at work in the knowledge system will encourage universities to construct structures which maximize their capacity for innovation. The common features of the entrepreneurial university mapped out earlier do not necessarily mean a uniform set of institutional structures has to be set in place. Nevertheless, many of the same organizational forms identified in the UK were earlier constructed in the US for much the same reasons (Ibid: 321).

- **Europe**

There are a variety of European circumstances that have made either stronger or weaker linkages between academic and corporate sectors. Yet, the European Commission regards “fruitful co-operation between universities and industries as one of the strongest engines of economic growth for Europe” (ESTA, 1997: 10), confirming the importance given to universities in relation to their role in economic development in the late 20th /early 21st centuries. The possibility of playing such a role does, however, vary by regions and countries, reflecting differences in the way both industry and academia have developed over this past century. With this sense it would be wrong to presume a single European model, either of linkage or of a university per se. We can sketch out some of these differences and similarities across a few European countries here, drawing on the work of Etzkowitz *et al.* (2000: 321-323).

- **Italy**

Italy’s attempt to overcome the conservatism of classical teaching universities seems to be stalled by the ongoing struggle to cope with administrative and budgetary problems. However, the financial crisis of the universities resulting from severe cut backs in public funding since 1980 has led to the introduction of new laws allowing universities the right to obtain private funding. Yet, the financial crisis of the public sector has left universities with a new autonomy without providing the managerial knowledge necessary to organize a for-profit range of activities. While public universities are blamed for mismanagement, inappropriate education schemes and inefficiency in matters of research, the polytechnics are more successful in finding industrial partners. The most famous ones, located in Milan and Turin, were set up by Olivetti and Fiat respectively to secure the recruitment of engineers for these founding firms (Etzkowitz *et al.* 2000: 322).

- **Germany**

The German story is one of redefining the university system to be both more active in regional development while being required to be prepared to generate higher levels of income through commercializing its teaching and research activity (Etzkowitz, H. *et al.* 2000: 323). The division between pure academic research and the more applied work of traditional universities is unlikely to persist in the future in practice since new networks linking basic and applied R&D that cut across institutional structures are developing. In response to the Hoechst's US\$50 million dollar contract with Massachusetts General Hospital in 1980, for example, Germany founded the 'Genecentrum' research centres in Cologne, Munich, Heidelberg, and Berlin. The objective was to create a critical mass of research activity in molecular biology, a field in which Germany lagged despite its strong commitment to biochemistry (Etzkowitz, H. *et al.* 2000: 323).

Almost two decades later, this initiative has borne fruit as participating scientists have begun to organize biotechnology firms, with as many as twelve founded in 1997. Generally, there is a tendency to adopt US methods to establish links with industries. Internships sponsored by companies and alumni organizations are getting more popular. On the other hand, larger companies like Daimler-Chrysler or Bertelsmann are planning to set up their own universities in order to avoid a long and difficult innovation process in the co-operation with university administrations (Etzkowitz *et al.* 2000: 323).

- **Latin America**

The classic Latin American University is undergoing gradual change in industrial development spurred by the shift in relations among industry, university and government. Traditional educational curricula designed to fit graduates into existing large bureaucratic organizations, whether governmental or industrial, are less relevant in the KBE where there is a premium on individuals with the varied skills necessary to work in new organizations and through networks. (Etzkowitz *et al.* 2000: 323).

Science policy in Brazil, and elsewhere in Latin America, has traditionally emphasized the priority of the national government. Indeed, major technology-based industries and universities were creatures of the state. The classic Latin American theory of science, industry and government, the eponymous 'Sabato triangle', postulated that the national state could play the leading role in restructuring their relationship. Thus, following the triangle model, the technology for milk

production in Colombia, for example, was analyzed by looking at government economic policy for the milk industry, the productive structure of milk products and how the science and technological infrastructure deals with milk problems (Etzkowitz *et al.* 2000: 324).

As in Eastern Europe and the former Soviet Union, having universities and industry as part of the same institutional sphere under the aegis of government was expected to facilitate technology transfer. However, in practice, there was often a gap rather than a close working relationship between developers and users (Mello *et al.*, 1998). Government supported research agencies had to guess what potentially useful areas of R&D would be helpful to industrial enterprises. Not surprisingly, they often missed the mark of what would work in a product (Ibid: 324).

- **Japan**

During the post-war era, the Japanese university mainly focused on training students for corporate and government employment. Currently there is a shift toward research, especially longer-term research with potential commercial implications. In anticipation of useful results, the protection of intellectual property originating in academia has become an issue. Since ownership resides with each individual professor, the concern is whether academics are willing or able to protect and commercialize their discoveries (Etzkowitz *et al.* 2000: 324-325).

Etzkowitz *et al.* (2000) stated that informal relations among academia and industry are a special Japanese cultural characteristic. When Japanese professors produced useful ideas, they were typically transferred to industry through informal relations with existing companies. When a company became interested in an academic research topic or when a firm faced a problem for which it needed outside research assistance, an industry research team would be sent on a visit to a relevant professor's research group. If the industrial researcher was interested in involving the academic in the problem-solving, research support/grant could be forthcoming and the industrial researcher might arrange for a longer stay. A parallel research effort would be established in the company lab, pursuing the more practical aspects of the topic. In these relationships, the academic researcher turned over the potential intellectual property to the company to patent. In turn, the academic received modest research support (Etzkowitz *et al.* 2000: 325). These Japanese characteristics are rather similar to Thailand's current cultural norm.

Japanese universities, once confined to the traditional industrial relations task of preparing students for jobs in Japanese firms, have taken on a new task. Formerly, companies wished mainly to hire persons with BA degrees, preferring to give specific training internally to ensure that it was in line with company goals. Japanese industrialists are rethinking this strategy. Universities are now expected to prepare more individuals with advanced degrees. These individuals will move into an environment with a higher degree of mobility among companies, within academia, and between academia and industry. Indeed an increasing number of Japanese universities now have high-level administrators who arrived from industrial research positions. In short we are beginning to see a much greater formalization of academia– industry ties in Japan (Etzkowitz *et al.* 2000: 325).

- **Thailand**

In Thailand's Eighth (1997-2001), Ninth (2002-2006), and Tenth (2007-2011) Economic and Social Development Plans, there has been an assignment for universities to support the industrial sector through research, innovation production and the generation of individuals with science- and technology-relevant industrial needs. Furthermore, the Thai government also supports firms and SMEs in the automotive and other sectors through science and technology related institutes/agencies, and government-sponsored organizations. Such plans aiming to pursue strategic clustering have been suggested by the commissioned work of Michael Porter of the Harvard Business School (2003).

Chulalongkorn University's study (2003) evaluated the extent of knowledge linkages among key actors of the North Bangkok Innovation Cluster (NBIC). An essential government-sponsored knowledge broker in the region is the National Science and Technology Development Agency (NSTDA) serving three specific clusters (electronics, automobiles and food) that are very much in line with NSTDA's expertise and governmental strategic industrial plans. In this study, organizations supporting clusters are expected to connect firms and research institutes in value chains, to support and involve relevant government agencies in industrial development, to provide training and educational programmes, to connect with financial institutions, to involve trade and professional associations, to support infrastructure and service providers, etc. The study suggested that NSTDA should play a major role in facilitating the development of NBIC. To further enhance cooperation between NSTDA and other actors in the cluster, for example, NSTDA should set up a high level working committee to oversee the NBIC; cluster managers/coordinators should be developed; and NSTDA's researchers should be trained to understand firms' innovation process and to be more entrepreneurial; and regular forums among NSTDA and firms in selected industries should be organized (Intarakumnerd and Chairatana, 2003: 13).

In addition to NSTDA, the Thai Society for Automotive Engineering (TSAE), based at Chulalongkorn University, is expected to play a critical role in connecting government, companies and universities through forums, technical assistance, lobbying and training. But relationships between TSAE and other players are on personal and informal bases, rather than being institutional or systemic.

Regarding the relationship between Thailand's automotive industry and universities, the National Economic and Social Development Board of Thailand's (2005) major strategies to develop manpower in the automotive industry that universities have roles within include:

(1) Increasing the capacity building of manpower production at engineering and technical levels through improving institutions' curricula at both levels as well as providing short courses that are subject-based and competency-based in the five areas of sheet metal forming, forging, metal casting, machining and plastic injection (The National Economic and Social Development Board of Thailand, 2005).

(2) Upgrading the existing workforce through training, an institute/programme for vocational qualification standards and an institute/programme for professional standard, as well as providing appropriate incentives to enhance the meaningful cooperation between educational institutions and the industry (The National Economic and Social Development Board of Thailand, 2005).

The financial crisis of 1997 and the intensive competition in the global market have made the industry and government realize the essential need for a shift of the relationship between universities and firms into one which is closer bound, to improve competitiveness of industry. In the next few years, Thai public universities will attain autonomous status as stated in the Education Act 1997; then public universities will be free from red-tape bureaucratic systems and enjoy more financial autonomy. Even though the government will continue to provide financial subsidies, universities are expected to generate more revenue from other sources, especially from the private sector. Therefore, universities have to stay relevant and serve industry in providing training, conducting research and engaging in other activities.

Recently, universities have increasingly attempted to increase industrial sponsorships and to forge linkages with industry through collaborative R&D, training activities, and internship programs

(College of Management, 2003) (Intarakumnerd, P. and Chairatana, P., 2003: 11). Interesting updates in this process are:

- (1) A number of smaller companies recently increased their technological efforts by collaborating with universities' R&D groups in order to stay competitive in the market. (Intarakumnerd, Chairatana and Tangchitpiboon, n.d.: 22).
- (2) King Mongkut's Institute of Technology, North Bangkok, for instance, has a joint venture with Hi-tech Industrial Estate to establish Ayutthaya Technical Training Centre to provide training for and facilitate recruitment of skilled workers for industries in the industrial estate, while the new centre received equipment and new technology from a number of participating Japanese companies (Brimble et.al, 1999 : 25 cited in Patarapong Intarakumnerd Pun-arj Chairatana and Tipawan Tangchitpiboon, n.d.: 23). (surnames only)
- (3) The Toyota Foundation donated equipment for practicum to Chulalongkorn University to support the establishment of a department of automotive engineering (Kojima, 2004: 162);
- (4) The Keidanren (Nippon Keidanren or the Japan Business Federation) supported the establishment of Thammasart University's Sirindhorn International Institute of Technology (SIIT) providing international programmes and research in science and engineering (JBIC 2003:104 cited in Kojima, 2004: 162). To support Thailand's education system, the Keidanren has also provided scholarships for students at the secondary level in the Northeast of Thailand, which have amounted to 2,000 baht per year each to 4,500 students since 1995 (Minoura and Notsu 1998:145 cited in Kojima, 2004: 162).
- (5) In 2002, Thailand's Commission on Higher Education pushed universities to set up cooperative education programmes involving students and instructors in industry-based projects. This programme is aimed to put universities- instructors and undergraduates – to join the industrial world and produce relevant graduates to serve industrial needs. As a return, universities could initiate relationships while understanding the demands and problems of industry to further develop research and programme to serve their needs. The early period of implementation found that policies from entrepreneurs, government and universities, the responsibility of universities' executives and instructors and achieving effectiveness from apprenticeships are instrumental in launching cooperative education programmes. In

contrast, inhibiting factors from undergraduates such as the lack of motivation and goals after graduation, the absence of a norm of hard work and the desire to graduate at the fastest pace are the major causes of cooperative education programmes being less successful at particular universities (Mongkhonvanich, 2006). Mongkhonvanich's study suggests measures delivering success involve three partners: government, universities and entrepreneurs. Government should communicate the core concept throughout faculty staffs, students and industries, and direct the coordination among related agencies; while universities should establish effective teams to prepare students' readiness to become involved. Entrepreneurs should assign vividly policy and group to support cooperative education programme whilst establishing stand-alone R&D to serve the purpose. In addition, universities should work together with entrepreneurs through expert exchange, conducting research, training courses and curricular development.

After all, it is important for different industry-related actors to interact to achieve competitiveness through their cooperation and competition that could create high values of products and services while improving effectiveness and efficiency.

However, Schiller (2006)'s study found that, *first*, the potentials of universities-industry linkages within the Thai innovation system are inhibited by a wide gap between absorptive capacities of private companies and knowledge production of universities. The scope of R&D and innovation activities by all players in Thailand is markedly lower than those in the advanced Asian NICs (Newly Industrial Countries). Recently, Thai universities put a stronger emphasis on applied research, but were unable to keep pace with the growth of industries. Because of their traditional orientation towards teaching, R&D at universities is growing slower than the commitment of the private economy in the field. Only a few flagship units at universities are likely to reach a level of research qualified for the industrially fruitful linkages of universities and industry (or even foreign enterprises). Co-operation with SMEs, which requires less research-intensity, is hampered mainly by low absorptive and financial capacities. As research expands in the university system, the potential supply of scientific services is incrementally improved.

Secondly, universities-industry linkages are limited to consulting and technical services, hampered by mutual distrust and faculty members' interest in receiving an extra personal income. At the

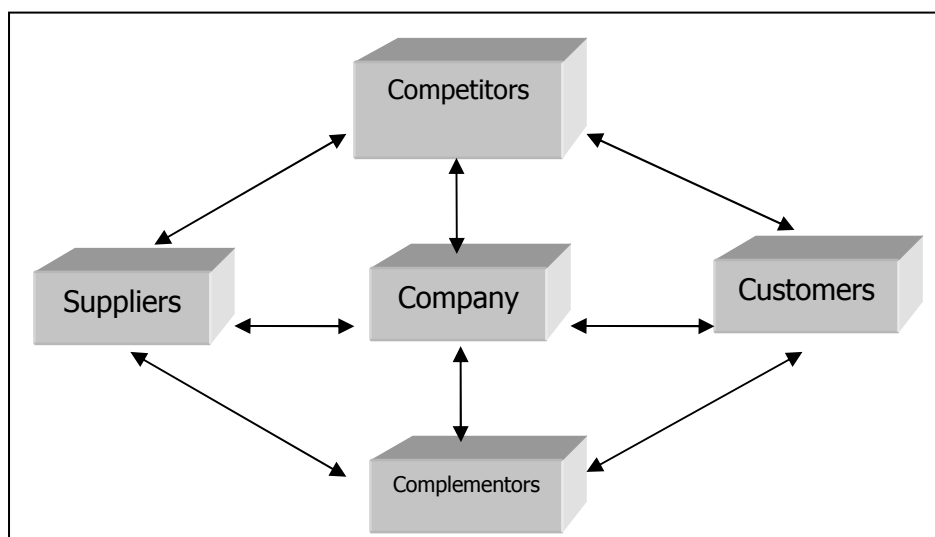
moment, most universities-industry linkages are based on personal contacts whilst operating without an institutional framework in research linkage. There is a lack of confidence in one another that needs an improved infrastructure of communication among players. And *third*, there are various ways to upgrade the Thai innovation system through universities-industry linkages in the future. SMEs in Thailand are suggested to step up their endeavours to build own technological capabilities - with assistance from governmental programmes - so as to achieve the capacity to cooperate with universities. At the same time, the content in university teaching and research should be harmonized with corporate demands and requirements. Nevertheless, the enhancement and relevance of Thai universities will require consistent substantial investments in scientific equipment and staff development. Meanwhile, to facilitate the establishment of cooperative relationships, bureaucratic obstacles should be gradually abolished while incentive structures are to be considered at the universities. The evaluation of professors/faculty members should no longer be based exclusively on their academic excellence, but also on other indicators such as the success of their co-operative relationships. Universities-industry linkages are greatly impeded by a lack of mutual trust among the players. Termed exchanges of employees/staffs between enterprises and universities might pave a way of trust building whilst learning more about the others' research and technological needs. Future research on the role of universities-industry linkages in the Thai innovation system should concentrate more in-depth on specific sectoral innovation systems to identify unique core competencies of sectors where university knowledge production and needs of multinational and local firms could mutually fertilize one another.

2.5 ‘Coopetition’: a framework for competitiveness

In most of the modern theories of business, competition is seen as one of the key forces that keep organizations/firms learning and drives innovation. The word “coopetition” itself is actually not new. The term was first used by the founder of the networking software company Novell, Ray Noorda, and became more popular after the 1997 book “Coopetition: The New Win/Win Game” written by Barry J. Nalebult and Adam Brandenburger. The authors argued that instead of seeing the game of business as one involving either losing or winning, a strategy of coopetition could be applied (Brandenburger and Nalebult, 1996; Lado, Boyd, and Hanlon, 1997; Gnyawali and Madhavan, 2001).

Coopetition is a business strategy based on a combination of cooperation and competition, derived from an understanding that business competitors can benefit when they work together. The coopetition business model is based on *games theory*, a scientific approach (developed during the Second World War) to understanding various strategies and outcomes through specifically designed games. While traditional business philosophy translates to games theory's *zero-sum game* in which the winner takes all, and the loser is left empty-handed; proponents of coopetition claim that it can lead to a *plus-sum game*, in which the sum of what is gained by all players is greater than the combined sum of what the players entered the game with.

The “coopetition model” starts out with a diagramming process called the *value net*, which is represented as a diamond shape, with four defined player designations at the corners: customers, suppliers, competitors and complementors. Complementors are defined as players whose product adds value to others; for example, software products gain value because hardware products coexist with them, and vice-versa. In comparison, a competitor is defined as someone whose product makes your product less valued; for example, a second brand of toothpaste would make the other similar one that had previously been in the market less valued (Figure 6) (Brandenburger and Nalebuff, 1996).



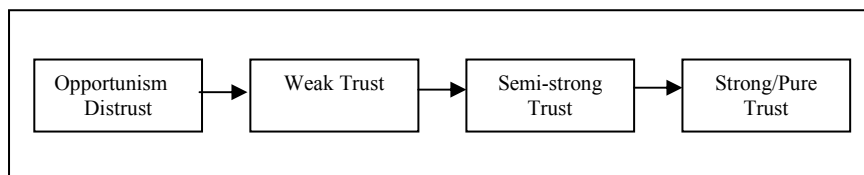
Source: Brandenburger and Nalebuff, 1996

Figure 6: Value net model

The cooperative perspective stems from 1) a source of economic value creation and a place for economic value sharing; 2) a variable-positive-sum game which may bring mutual but not necessarily fair benefits to the partners because of several competitive pressures that may undermine

their coopetitive structure; 3) a variable-sum game structure in which firms' interdependence is based on a partially convergent inter-firm interest function (Dagnino and Padula, 2002).

The combined structure of cooperation and competition creates the development of trust in a cooperative context (Grandori, 1999). If control processes carried out by the partners are sensibly weakened, it may result in an incentive, to one or more partners, to behave opportunistically. According to Williamson (1985) and Barney and Hansen (1994), inter-firm relationship could first be modelled in distrust/opportunist forms and these forms can then be positioned through a continuum of experiences which goes from opportunism/distrust to strong trust (Figure 7), in a process which might be useful in interpreting inter-firm coopetitive's exchanges.



Source: Dagnino and Padula, 2002

Figure 7: Forms of trust in a continuum

The typology of inter-firm coopetition is based on two forms of coopetition: dyadic coopetition and network coopetition.

- 1) *Dyadic coopetition* refers to firm dyads or two-firm relationships relating to: a) coopetitive (both competitive and cooperative) relationships between the similar two firms along one single level of the value chain (i.e., strategic consortia as R&D consortia). This is what is termed 'simple dyadic coopetition'; b) coopetitive (competitive and cooperative) relationships between the similar two firms along several levels of the value chain (i.e., a number of firm dyads in the automobile industry who cooperate on car R&D and/or production and compete in car distribution). This is what is named 'complex dyadic coopetition'.

- 1.1) Simple dyadic coopetition becomes evident through considering a basic strategic dyadic alliance, such as R&D consortia. An R&D consortium is a legal entity established by two (or more) organizations that pool resources and share decision making for coopetitive research and development activities (i.e. at same level of the value chain).

- 1.2) Complex dyadic coopetition is apparent if we consider a number of recent alliances in the automobile sector (i.e., BMW-Daimler Chrysler, Ford-PSA, Honda-Isuzu, Fiat-GM, Opel-Renault, PSA-Toyota, Opel-Suzuki and Volkswagen-Porsche) which offer a fair representation of the heretofore described structure of coopetition strategy. These agreements assume different forms and focus on cooperation in R&D and manufacturing of one or more car components or product lines (i.e., automatic gears, diesel or petrol engines, sports or utility cars, vans, or commercial trucks)
- 2) *Network coopetition* concerns a structure of complex relationships among more than two firms at the same time and links up with: a) coopetition (competitive and cooperative relations) among multiple firms along one single level of the value chain (i.e., buyer-supplier relationships known as ‘parallel sourcing’). This is ‘simple network coopetition’; b) coopetition (competitive and cooperative relations) among multiple firms along several levels of the value chain (i.e., industrial districts, firm clusters and multilateral agreements). This is ‘complex network coopetition’.
- 2.1) Simple network coopetition is represented by coopetition among multiple firms at one level of the value chain. For example, in buyer-supplier relationship in Japanese car manufacturing known under the label of ‘parallel sourcing’, auto components parallel sourcers (i.e., Toyota) usually select two or more suppliers, at least one of which coming from the internal market. These choices allow Japanese car makers to keep their supplier under the continuous pressure of the relentless menace of potential competition from the exclusive suppliers of similar components for the same final product or of the same component for different final products, or eventually of upward vertical integration from the same buyer firm. This peculiar relational structure is aimed to keep a constant and intensive transfer of material and information on process techniques among the participants in the supply chain. Commitment to long-term cooperation need not imply abandonment of competition among suppliers. In fact, Japanese automakers have traditionally relied on multiple suppliers embedded in a multi-tier system for a higher share of their externally sourced parts than did their US counterparts. Enhancing competition and cooperation lies in a willingness of automakers to work with a supplier to solve technical and economic problems, rather than simply switching from a supplier to another.

2.2) Complex network coopetition is epitomized by a number of Italian industrial districts (i.e., Valenza Po for gold jewelry, Carpi for knitwear & sweaters, Parma for cured ham and parmesan cheese, Prato for textiles & clothing). The concentration of small and medium firms in these aggregate bodies unveils a model of a tightly connected dynamic fabric of multiple relationships which intervene at different levels, presenting high self-organizing power in that they usually cover all the value net of production and distribution. For example, major players in the tyre industry such as Michelin, Goodyear, Pirelli, and Dunlop have jointly designed the ‘pax system’ available as an optional part on the Renault Scenic model and forthcoming on some Audi automobiles.

Dagnino and Padula (2002) suggest that coopetition is a matter of “incomplete interest (and goal) congruence” concerning firms’ interdependence, they stress that coopetition does not simply emerge from coupling competition with cooperation, but rather it implies that cooperation and competition merge together to form a new kind of strategic interdependence between firms, giving rise to a *coopetitive system of value creation*.

2.6 Conceptual framework

Theories and concepts

The conceptual framework for this study is based on three main, related and nested theories and ideas:

1) ***Globalization and Knowledge Economy*** have recently increased their role in economy and society and could lead to the two perspectives of what have taken place:

- **Colonial view:** Enhancing globalization and the knowledge-based economy is the way economically powerful countries are to retain and increase their power. Many argue that this is economic colonization by the developed through foreign direct investment, global institutions, market fundamentalism, multinational organizations/agreements, etc. Developed countries usually exploit underdeveloped and developing countries through resources and low-cost labour to further accumulate wealth. To retain the exploitation,

they do not transfer technology and skill to host economies. Thus, it is unlikely that underdeveloped and developing countries will become competitive in the longer-term.

- **Developmental view:** Globalization and the knowledge economy provide countries with opportunities to develop knowledge, skills, infrastructure, well-being of people and the economy (even though the colonial view is more likely to be the case). To become a better-off player under globalization and a knowledge-based economy, underdeveloped and developing countries must improve their competitiveness through human capital and knowledge development (leading to other developments). Then, universities, as a major resource for human capital and knowledge development, could play an important developmental role in the knowledge economy.

These two views rather provide different scenes and results of globalization and knowledge-based economy. It is important for an economy to realize the two views and implement strategies according to its vision and desired outcome.

2) ***Coopetition*** is a business strategy based on a combination of cooperation and competition, derived from an understanding that business competitors can benefit when they work together. The combined structure of cooperation and competition creates the development of trust in a cooperative context (Grandori, 1999). If controlling/monitoring processes carried out by partners are weakened, it may result in an incentive for one or more partners to behave opportunistically. A coopetition framework will be used to understand and analyze interaction among players in industry.

3) The “***triple helix***” refers to the multiple reciprocal relationships among institutional sectors (public, private and academic) at different points in the knowledge capitalization process. The concept of a regional innovation environment consists of the set of political, industrial and academic institutions that, by design or unintended consequence, works to improve the local condition for innovation and includes the concept of social capital, which refers to the density of social relationship and trust in interpersonal relationship.

This research study will use the “triple helix model” as the framework for understanding and analyzing the relationship between Thai universities and the Thai automotive cluster. The “triple helix” is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. The first dimension of the triple helix model is

internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of economic development mission by universities. The second is the influence of one helix upon another. An example is the role of the government in instituting an indirect industrial policy through sponsoring research and technology transfer activities throughout a broader range of universities, resulting in the emergence of an academic technology transfer profession. The third dimension is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices for the purpose of coordination and generation of new ideas and formats for high-tech development.

The triple helix denotes the university-industry-government relationship as one of relatively equal, interdependent, institutional spheres which overlap and take the role of one another. Bilateral relations between government and university, academia and industry and government and industry have expanded into triadic relationships among the spheres. Academic-industry-government relations are emerging from different institutional starting points in various parts of the world, but for the common purpose of stimulating knowledge-based economic development (Etzkowitz, 2002).

Theories into Conceptual Framework

The current interactions in Thailand among university, industry and government (U-I-G) are a Laissez Faire relationship of separate institutional spheres; each seems to act competitively rather than cooperatively in their relations with one another. The institutional spheres lead to strong boundaries inhibiting interaction among the institutional spheres (shown in Figure 8's Current Linkages of U-I-G in Thailand's Automotive Industry).

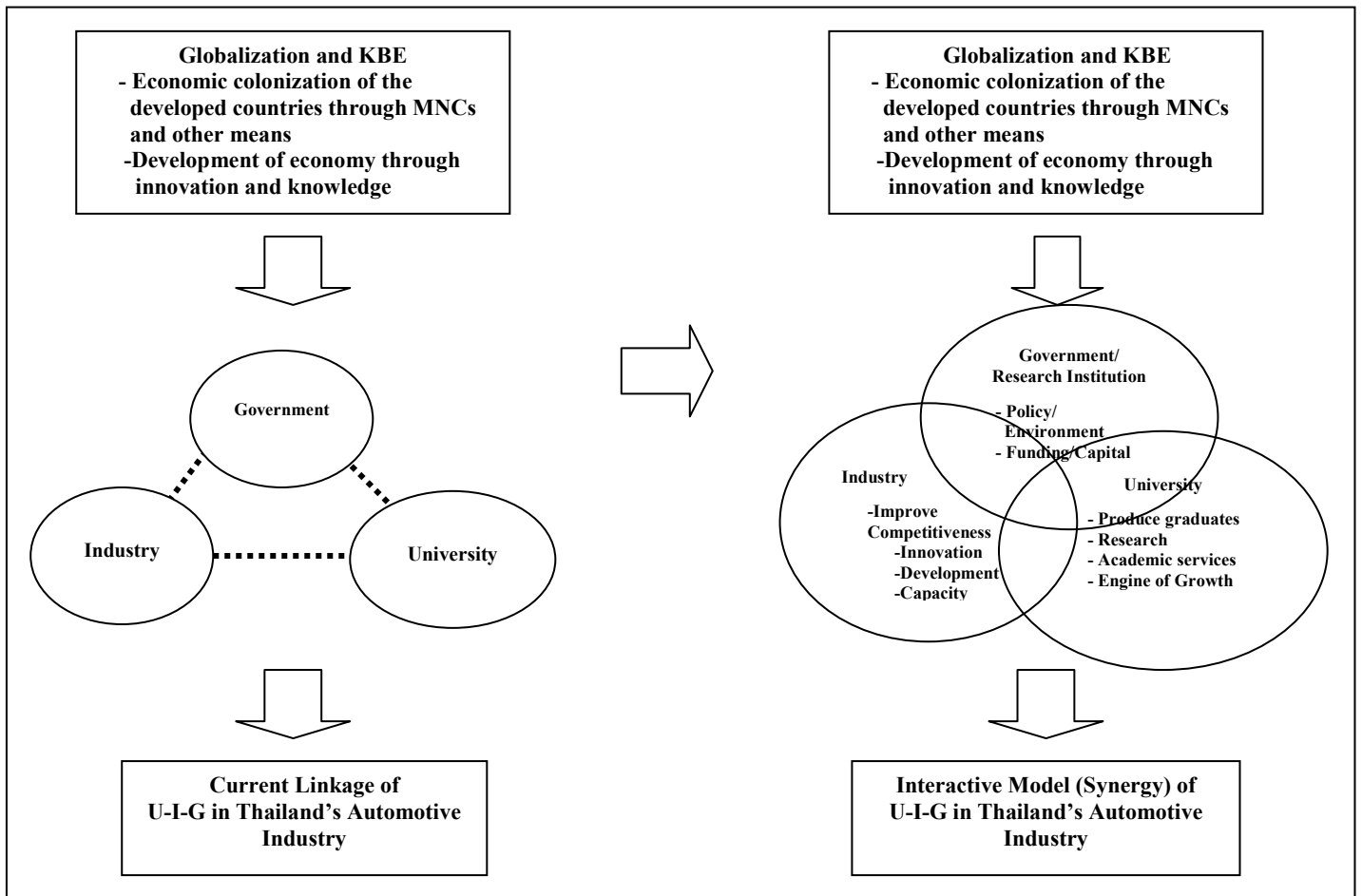
However, the spheres in reality are often closer in relationship than that of the Laissez Faire model of relationship among U-I-G operating in their own areas without close connection. For example, Thai universities are providers of basic research and trained personnel. Their roles in connection with industry are to supply knowledge, mainly in the form of publications and graduates, who bring tacit knowledge with them to their new jobs. It depends on industry whether they find / exploit useful knowledge and graduates from the universities without receiving cooperation or much assistance from the universities.

In the Triple Helix model, a new set of interactions among U-I-G moves toward the convergence of innovation regimes. The increased interaction among U-I-G as relatively equal partners, and the new

development innovation strategies and practices that arise from this cooperation are the core of the Triple Helix model of economic and social development. The Triple Helix also becomes a platform for “institution formation,” the efforts of different players to create new organizational formats to promote innovation, such as the incubator, Science Park, and the venture capital firm. These new organizations arise from interaction among U-I-G to promote innovation and are themselves a synthesis of elements of the Triple Helix (Eztkowitz, 2003: 307-308).

With the triple helix model of relationships among U-I-G, the theories/frameworks regarding globalization and knowledge economy and coopetition are to be used to explain and analyze the economic development of the automotive cluster as an outcome of such relationships.

The conceptual framework in the case study of relationships between university, industry, and government in Thailand’s automotive cluster concentrates on the existing relationships and finding the appropriate model to strengthen Thai auto-part manufacturers’ innovation. The conceptual framework incorporating the three theories/frameworks to achieve the objectives of the study is shown in Figure 8.



Source: Adapted from Etzkowitz, H. and Leydesdorff, L., 2000: 111

Figure 8: Conceptual framework: relationship between U-I-G in Thailand's automotive industry

Chapter 3

Research Design and Methodology

3.1 Overview

The purposes of this research are to examine the position of the Thai automotive cluster in the context of the knowledge-based economy and economic competitiveness in order to identify the dynamics of the relationship between universities and the automotive cluster, and to recommend the tasks and roles of universities to meet the demand of the automotive cluster in the knowledge-based economy.

This research study uses a “Triple Helix” model as the framework for understanding and analyzing the relationship between Thai universities and automotive industry under the knowledge economy. It is to employ multiple surveying methods, including questionnaires and in-depth interviews, to investigate the relationship between government, universities and the automotive cluster. This chapter will provide a rationale for the methodology adopted, discuss the research design and implementation and outline the modes of data analysis to be employed. It begins with a reminder of the research objectives and questions, as a necessary basis for establishing the validity of the research design.

3.2 Research Objectives

The objectives and questions to be answered in the study of the relationship between university and industry in the knowledge economy are the following:

1. To investigate the linkages and relationship between university and industry in the knowledge economy
 - Research Question: What is the nature of the linkages and relationship between university and industry in Thailand’s Automotive Cluster?

- i. What factors influence the relationship and what are their relative significances?
 - ii. At what level do universities serve automotive industrial needs? Why is it the case?
- 2. To find applicable models to improve the linkages, in order to enhance industrial competitiveness
 - Research Question: What recommendations can be made to address the problems in university-industry linkages and to improve such relationships to better serve the economy?
 - i. How can universities improve to better serve Thailand's Automotive Cluster in enhancing competitiveness and sustainability?

3.3 Hypothesis

The greater the reliance of the economy on intensity of knowledge, the greater is the significance of universities' role in the economy. Thus, universities, as a promising source of knowledge, need to play active roles in enhancing industrial competitiveness for the economic development of a nation.

3.4 Types of Data Required

According to Punch (1998: p.57), 'The connection from content to method is through data.' Therefore, the research design begins with the types of data needed to answer the research questions. This study is designed with the objective of yielding appropriate and sufficient data that would allow me to answer the research questions mentioned above. The study demands 1) general yet precise descriptive data and perspectives on the linkages between industry and universities in Thailand's automotive cluster; 2) in-depth information from universities and companies on their perspectives on existing linkages and relationships to find out about such dynamics and make appropriate recommendations.

The data required above, involving general views of existing relationships between industry and universities and in-depth data on perspectives of the both parties, can be obtained through a combination of quantitative and qualitative methods.

3.5 Research Methodology

3.5.1 Discussion of Research Approach

Social research methodology is often categorized into quantitative and qualitative methods that are based on contrasting philosophical positions and constitute distinct research paradigms.

Quantitative research lies in with the research paradigm of positivism, referring to a research tradition derived from the natural sciences. It allies with realists who assert the fact of the world and external reality (Scott and Usher, 1999). Positivism defines its epistemological assumptions as objectivism, suggesting that knowledge and facts exist in the form of time- and context-free generalization and are available for those seeking to know them (Guba and Lincoln, 1994; Scott and Usher, 1999). From a positivist perspective, social research purposefully targets explanation, prediction and control of the objective world; while its measurement relies on hypothesizing and numerical data (Guba and Lincoln, 1994; May, 2001). Quantitative researchers often start with general picture of a social issue and then investigate a particular aspect to test the strength of assumed theories through empirical evidence (May, 2001). In addition, quantitative research, within the positivist paradigm, conceptualizes reality through variables and their relationships in a conceptual framework.

In contrast with quantitative methods, qualitative research is located within the interpretivist paradigm, which may be considered as anti-positivism. The interpretivist paradigm affirms a relativist perspective that sees realities existing in the form of multiple mental constructions based on differential socialization and experiences. The construction of realities is an outcome of interaction between active subjects and the world (Giddens, 1976). Interpretivism argues that the social world can only be understood through the perspectives of individuals involved in ongoing activities and

relationships. Interpretivists align with an epistemological position of subjectivity, regarding knowledge as a human construct. Qualitative research is thus for the purpose of explaining and understanding social relationships and events through the direct experiences and interpretation of individuals (Sarantakos, 1998; Cohen, et al, 2000). Qualitative research usually aims at generating theoretical propositions on social events through data (May, 2001).

With the arguments and the standpoints of both quantitative and qualitative research methods, many scholars agree that a single approach may not be successful in explaining social events and relationships in their full complexity (Schulze, 2003). Pluralism in methodologies and approaches are then useful, as the combination of quantitative and qualitative approaches are advocated for the triangulation across multiple sources to better understand the context and reality in breadth and depth (Sayer, 1992; Creswell, 2003; Schulze, 2003). Sarantakos (1998) points out that triangulation allow the researcher to:

- Obtain a variety of information on the same issue
- Use the strengths of each method to overcome the deficiencies of the other
- Achieve a higher degree of validity and reliability

In this study, I employ a combination of quantitative and qualitative research methods. This research undertakes to fulfil two major objectives. First, since little research has been done in the relationship between universities and industry within Thailand's automotive cluster, it is useful and helpful to commence the research through the generation of a general picture of linkages and relationships between universities and industries in Thailand's automotive cluster. This general picture of the linkages and relationship is best obtained and understood through the use of quantitative methods, comprising a survey of automotive companies in the Thailand's automotive cluster, to find general statistics and perspectives of firms in the cluster. In this study, I employ the population of 100 auto-part companies in the Thailand's automotive cluster in Samutprakarn, the most important automotive cluster in the country due to its size, economic value and history, that are sizable and justifies employing a quantitative survey to better understand the context.

Second, the main objective of this research is to understand perspectives, opinions and experiences of individuals involved in the relationship between universities and industry on different issues and experiences regarding the relationship and development of the automotive cluster/industry in Thailand. A qualitative method based on an interpretivist and constructivist approach, comprising in-depth interviews, is adopted to further investigate related issues, experiences and opinions on the relationship and to generate recommendations to bring about improvement. In-depth interviews are held with individuals in automotive firms and universities. Besides, to better understand such relationships, I also interviewed leaders of related institutes/organizations to find perspectives on these relationships from third parties that have a significant role in the industry, as the Triple Helix model of U-I-G relations suggests (Etzkowitz and Leydesdorff, 2003).

3.5.2 Population and the sample

- ***Population of the study***

The units of analysis of this study comprise three groups; Thai automotive firms, universities, and related institutes/organizations.

- 1) The automotive companies comprise 1,748 places located in 7 automotive industrial clusters concentrated in provincial areas. Samutprakarn's cluster, consisting of foreign and local auto-assemblers and auto-part producers, is however well-regarded as the Thai automotive cluster due to its size, economic value and history. The Samutprarn's cluster is the oldest and largest automotive cluster in the country in the country with 70 kilometres radius of Bangkok. In the Samutprakarn's cluster, there are 100 auto-part producers and 5 assembly plants (see Table 1 below)
- 2) Of the country's 190 universities (78 public, 63 private, 40 public Rajabhat Universities upgraded from teacher-training colleges, and 9 public Rajamangla Universities upgraded from technical colleges) those which have operated machinery engineering and automotive engineering courses total 40: 26 public universities and 14 private universities (Chiasakul,S.,2004: 5-6 and Commission on Higher Education, <http://www.mua.go.th/default1.php>).

- 3) The 5 automotive-related institutes embrace the National Metal and Materials Technology Centre (MTEC), the research institute related to Thai automotive industry, and Thailand Automotive Institute, Thai Auto-Parts Manufacturers Association, Thailand's Society of Automotive Engineer - (TSAE), and Thai Automotive Industry Association.

• ***The sample and sampling techniques***

The sample for this study is obtained through a purposive sampling technique as follows:

- 1) This study selects Samutprakarn's automotive cluster as the case study because it is the oldest and largest automotive cluster in Thailand and is located on the periphery of Bangkok where there are universities of high reputation nearby. The population of Samutprakarn's auto-part producers (100 automotive part companies) and Toyota Motor (Thailand) Co., Ltd. -the oldest and largest assembler in Thailand- are our sample out of Samutprakarn's automotive cluster. All firms in this sample hold membership of the Thailand Automotive Institute. This research also picks Thairung Union Car Public Co., Ltd in Samutsakorn (west of Bangkok), the only Thai auto-assembler in the country, as another constituent of the sample of assemblers to understand the dynamics of Thai assembler and universities, as it serves the objectives of the study (see table 3 and 4);

Table 3: Location of Automotive Assembly Plants in Thailand

Chonburi	Samatprakarn	Samutsakorn	Bangkok	Chachoengsao	Rayong
-MMC Sittiphol (Mitsubishi)	-Toyota Motor Thailand -Isuzu Motors -Siam Nissan Automotive -Siam V.M.C Automotive -Thai Auto Work	-Thai Rung Union Car -Thai Swedish (Volvo) -Thonburi Auto Assemble	-Bangchan General Assembly -Hino Motors (Thailand)	-Toyota Motor Thailand	-Auto Alliance (Thailand) -GM(Thailand)

Source: Thailand Automotive Industry Association; In Chiasakul, 2004: 5

Table 4: Firms comprising the sample of auto-part manufacturers within the Thai Automotive Cluster (Samutprakarn's)

No.	Name	No.	Name
1	Ampas Industries Co., Ltd.	51	K.N.P. (1994) Co., Ltd.
2	Enkei Thai Co., Ltd.	52	T S A Rubber Product Co., Ltd.
3	Asia Precision Co., Ltd.	53	Thai Summit Mold Manufacturing Co., Ltd.
4	Thai Metro Industry (1973) Co., Ltd.	54	Thai Summit R&D Next Technology Co., Ltd.
5	Bangkok Spring Industrial Co., Ltd.	55	Metatech Co., Ltd.
6	Chaiyaparn Engineering Co., Ltd.	56	Somboonsiri Limited Partnership
7	DuPont Performance Coatings (Thailand) Ltd.	57	Cheowchan Industry (1989) Co., Ltd.
8	Thai Decal Co., Ltd.	58	Matsushita Electronic Components (Thailand) Co., Ltd.
9	Somboon Malleable Iron Industrial Co., Ltd.	59	Summit Auto Body Industry Co., Ltd.
10	Thaifujioka Co., Ltd.	60	United Coil Center Co., Ltd.
11	Siam Kayaba Co., Ltd.	61	NanoShield & Royal Ace Co., Ltd.
12	Thai Summit Harness Co., Ltd.	62	Thai C.L.Industry Cable Co., Ltd.
13	Charoenlap Auto Part Co., Ltd.	63	Sooksawat Kolakarn Ltd.Part
14	SNN Tools & Dies Co., Ltd.	64	K.C.E. International Co., Ltd.
15	Summit Steering Wheel Co., Ltd.	65	Unit Parts Commercial Limited Partnerchip
16	K.K. Sparepart Co., Ltd.	66	Decho Mould & Die - Casting Co., Ltd.
17	Sang Charoen Tools Center Co., Ltd.	67	B.K.J.Engineering Co., Ltd.
18	Siam Chita Co., Ltd.	68	Katsuya (Thailand) Co.,Ltd.
19	Summit Auto Seats Industry Co., Ltd.	69	Thai Storage Battery Public Co., Ltd.
20	Armstrong Rubber & Chemical Products Co., Ltd.	70	Siam Fukoku Co., Ltd.
21	T.S.K. Factory Co., Ltd.	71	C.N.C. Parts Co., Ltd.
22	Thai Harnes Co., Ltd.	72	Faratech Co., Ltd.
23	Thai Yang Kitpaisan Co., Ltd.	73	M.N.Auto Part Co., Ltd.
24	Srithai Auto Seats Industry Co., Ltd.	74	T H A Coating Co., Ltd.
25	P.C. Products International Co., Ltd.	75	Saha Autopart Industry Co., Ltd.
26	Denso (Thailand) Co., Ltd.	76	Quality Coat Co., Ltd.
27	S.Y.K. Spare Parts Industrial Co., Ltd.	77	Thai Steel Service Center Ltd.
28	T.S. Intertech Co., Ltd.	78	Thai Yamaha Motor Co., Ltd.
29	Feltol Manufacturing Co., Ltd.	79	Thai Asahi Denki Co., Ltd.
30	O.E.I. Parts Co., Ltd.	80	CH. Watanayont Co., Ltd.
31	CH. Auto Parts Co., Ltd.	81	Thai Summit PKK Bangna Co., Ltd.
32	C.M. Industry Co., Ltd.	82	C.H.Radiators Co., Ltd.

No.	Name	No.	Name
33	Rosti (Mala) Ltd.	83	Murakami Ampas (Thailand) Co., Ltd.
34	Siam GS Battery Co., Ltd.	84	Thai Tech Die And Part Co., Ltd.
35	Thai Automotive Industry Co., Ltd.	85	Udom Pipatmongkol Limited Partnership
36	Far-Sight Sahakij Co., Ltd.	86	TOA-Shinto (Thailand) Co., Ltd.
37	Nissei Trading (Thailand) Co., Ltd.	87	Shibata Giken (Thailand) Ltd., Part
38	A.A.A. Manufacturing Co., Ltd.	88	TTS Engineering Products Co., Ltd.
39	Inter-Hides & Leather Co., Ltd.	89	General Spring Center Co., Ltd.
40	Siam Motors & Nissan Co., Ltd.	90	C.S. Engineering Autopart Co., Ltd.
41	S.P. Metal Parts Co., Ltd.	91	NSA Industry Co., Ltd.
42	Thai Parkerizing Co., Ltd.	92	CHL Heattreatment Co., Ltd.
43	Thai Summit Autoparts Industry Co., Ltd.	93	Pullthana Part and Mold Co., Ltd.
44	Precipart Co., Ltd.	94	Tac Siam Corp Ltd.
45	New Somthai Motor Work Co., Ltd.	95	K.D.K. Die And Parts Co., Ltd.
46	Thai Chanathorn Industry Co., Ltd.	96	Charoenphol II Engineering Co., Ltd.
47	Mahajak Industry Co., Ltd.	97	Sang Rung Ruang Engineering Co., Ltd.
48	Bangkok Diecasting And Indection Co., Ltd.	98	CNS Parts Manufacturing Co., Ltd.
49	Millenium Motors Co., Ltd.	99	GRP. Hightech Ltd., Part
50	Narong Industrial Public Co., Ltd.	100	Somboon Advance Technology Co., Ltd.

2) Eight universities that have machinery and automotive engineering courses are chosen for this study. These encompass 6 public universities representing the 26 public universities, namely, Chulalongkorn University, King Mongkut's Institute of Technology North Bangkok, King Mongkut's Institute of Technology Ladkrabang, King Mongkut's University of Technology Thonburi, Rajamangala University of Technology Thanyaburi, Rajamangala University of Technology Phra Nakhon North Bangkon and 2 private universities representing the 14 private universities, namely, Mahnakorn University of Technology, and Siam University (Appendix B).

To ensure a cross-section of universities that represents the field, the selection of these universities is justified as follows:

- King Mongkut's Institute of Technology Ladkrabang is taken to belong to the cluster because of its location in Samutprakarn. In addition, it is one of the most competitive engineering schools (in terms of the national university's entrance

scheme) and has a strong reputation in science and technology including mechanical and automotive engineering;

- Chulalongkorn University, established by King Chulalongkorn, is the foremost and oldest university, with a good reputation in science and technology, including mechanical and automotive engineering. Thailand's Association for Automotive Engineering (TSAE) is located in this university;
- King Mongkut's Institute of Technology North Bangkok, King Mongkut's University of Technology Thonburi, Rajamangala University of Technology Thanyaburi and Rajamangala University of Technology Phra Nakhon North Bangkok are well-regarded technological universities with good reputations in mechanical and automotive engineering;
- Mahanakorn University of Technology is a private university known for its engineering school, recognized in international universities' rankings (including Asia Week) and it is located close to the cluster;
- Siam University is a comprehensive private university having automotive engineering but located more than 80 kilometres away from the cluster.

3.5.3 Data Sources

- 1) Secondary data are obtained through literature survey and collection of secondary sources, notably government documents and automotive information reports.
- 2) Primary data sources are a questionnaire survey given to automotive firms and in-depth interviews with key personnel in universities and related institutes.

- ***Data Collection's Instrument for Automotive Industry***

(1) The researcher reviewed (literature review in Chapter 2) the concept, theory, and research related to "Relationship between universities and automotive industry in knowledge economy," including definition and variables, namely,

- Firm's policy on competitiveness;
- Development of industry and innovation:
 - Knowledge management;
 - Technology development;

- Human Resource development;
 - Marketing;
 - Productivity.
 - The relationship of companies with universities, research institutes, and related organizations to improve competitiveness and innovation.
- (2) Operational definitions of the following are then identified as shown in Appendix C:

- Firm's competitiveness;
- Relationship with universities, research institutes, and related organizations to develop competitive advantage.

- (3) The researcher selected questionnaire as data collection method to understand automotive industry's context through mailed survey and used semi-structured interviews (interview guide) as instrument for in-depth interview of automotive companies, universities and related organization to obtain further information and perspectives.

- ***Questionnaire***

The researcher decided on closed-ended questions as the major format while using only a few open-ended questions that demand insights and perspectives. Most of measurement scales are nominal and ordinal scale.

Questionnaire was developed from identified operational definitions as I mentioned above, while questions were developed accordingly and arranged into 4 parts (see Appendix D):

- Part 1: Questions on automotive part firm's linkage with university and other institutes;
- Part 2: Questions on benefit of firms through university's contact;
- Part 3: Questions on expectation of support from university and how to make the relationship more meaningful;
- Part 4: Company profile.

Before sending the survey to the actual sample, two professors in automotive engineering department at King Mongkut's Institute of Technology North Bangkok

and one professor from Siam University who have extensive experience in the field were asked to complete the questionnaire to pre-test and discuss their reactions on content validity with the researcher. Their responses were used to further refine the questionnaire. As a result, several questions were reworded to reduce confusion, and items that appeared to be somewhat sensitive which respondents did not desire to answer were improved.

After the questionnaire had been refined, the researcher pretested questionnaires and discussed with two companies -executives of Musashi Auto Parts Co., Ltd. and TR Technical Centre Co., Ltd.- three weeks apart each on their reaction while obtaining information on language clarity, the structure and contents, the difficulties and problems on responding and content consistency. Results from discussion are used to further revising the instrument for reliability before the actual data collection (see Appendix D).

- ***Interview Guide for In-depth Interviews***

The researcher went through the same first two stages (1-2) of questionnaires' development above and planned to conduct semi-structured interviews to obtain related information and perspectives on the dynamics of the relationships among universities, industry, research institutes / related organization, and government. The researcher developed issues that are important to explain further details from what the study received from the companies' data collected through questionnaire (In other words, data from interview should be able to explain "why" factors influencing the U-I-G-organization/institute relationship and "how" U-G-organization/institute be improved to better serve Thailand's automotive cluster in enhancing competitiveness and sustainability). The guide's topics cover the interviewee's policy and its implementation on the following issues;

- **Universities**

In relation to the conceptual framework, the study determines the variables for the relation model. The university variables are the policy and functions, namely,

- University's policy and infrastructure

- University's policy on improving the linkage and relationship between U-I-G-related organization/institute to better serve Thailand's automotive cluster in enhancing competitiveness and sustainability;
- The positive attitude of the university toward industrial development;
- The reputation and prestige anchoring high technology in industry;
- The high quality in automotive engineering and management;
- Funding from external sources;
- Proximity between cluster and university.
- University's functions
 - Producing graduates
 - Industrially relevant skill-training in undergraduate (automotive engineering) course;
 - Graduates and post-doctorates in engineering.
 - Research
 - Ready-to-use codified useful knowledge for supporting cluster;
 - Industry's research partnership;
 - Research for innovation and invention;
 - Intellectual property rights, commercial development, and competitive research.
 - Academic services
 - Technology transfer from university to firm;
 - Industrial extension and technical assistance;
 - Entrepreneurial development;
 - Industry's education and training partnership, career services and placement;
 - Incubation service.
- The relations with firms and other organizations are as follows:
 - Formal relation;
 - Informal relation.

- **Firms**

The firm variables are the policy and development, namely,

- Firm's policy on competitiveness;
- Development of industry and innovation

- Knowledge management;
- Technology development;
- Human Resource development;
- Marketing development;
- Productivity development.
- The relationship with universities, research institutes, and related organizations to develop innovation.

○ **Research institutes**

The research institute's variables are the policy and the collaboration support to the universities and firms, namely,

- Research institutes' policy on collaboration supporting to universities and firms for enhancing firm's competitiveness;
- Academic support;
- Financial support;
- Academic collaboration;
- Technology transfer.

○ **Related organizations**

The revolving organization variables are the policy and collaboration support to firms and universities, namely,

- Policy on collaboration supporting to universities and firms for enhancing firm's competitiveness;
- Establishment of collaboration;
- Academic support and collaboration;
- Financial support to universities and firms for developing research innovation.

○ **Government**

The government variables are as follows:

- Policy and commitment to support Thai automotive industry;
- Financial support to universities and revolving organizations;
- Establishment of forum and cluster of industry-universities;

- Policy to establish testing equipment and service centre to support industry;
- Policy to encourage collaboration between universities-industry-related organizations-research institutes.

Regarding the interview guide for universities, the researcher sent the interview guide to three professors in automotive engineering - two professors from King Mongkut's Institute of Technology North Bangkok and one professor from Siam University - who have extensive experience in the field to discuss their reaction on content validity. Their responses were used to further refine the interview guide and remark for information probing. After that pre-testing the modified instrument with the director of Science and Technology Research Center of King Mongkut's Institute of Technology North Bangkok and then discuss about content and more useful recommendation with her. I eventually adjusted the question for the final version of in-depth interview guide (see Appendix D).

3.5.4 Data collection

○ *Mail survey*

The survey was implemented by mail during March to June 2007. The researcher contacted all targeted firms by calling and e-mailing to determine the appropriate contact persons and to confirm addresses for the mail survey. Letters explaining the purposes of the study were sent to all samples. Approximately a week after the letters were mailed, a questionnaire package was sent to all firms in the sample. To encourage all firms to respond, the researcher took the following actions:

- A "thank you/reminder" letter was mailed within 10 days after the mailing of full questionnaire;
- Calling and e-mail to remind respondents to complete the mail survey if they had not done so.

• Response rate

The overall response rate for the mail survey was 50 percent with the remaining non-respondents (50 firms) failed to return their questionnaires. Dillman (2000) argues

that a mail survey is highly valid when the response rate lies between 58 to 92 percent; an average rate of the 74 percent. Dillman believes that the mentioned response rate could be achieved when pursuing measures such as incentives and multiple contacts. The researcher followed Dillman's Tailored Design Method, but the response rate for the mail survey was only 50 percent. However, it is anticipated that valuable information and insights are derived from the data because respondents include representation of companies with different sizes and ownership (Thai companies, foreign companies and joint ventures).

○ *In-depth interview*

The in-depth interviews were conducted during June to September 2007. The researcher contacted potential interviewees and described to them the purpose of the interviews. After interviewees agreed with an interview time and date, a confirmation letter, or e-mail message, and a list of general topics to be covered were sent to interviewees. The researcher used the interview guide (see Appendix D) to provide some structure to the interviews but did not strictly follow the pattern.

The researcher interviewed the participants from 8 universities, 1 research institute, 4 related organizations, and 3 companies (auto-part producer and auto assembler) one-at-a time (see Table 5 and Appendix E).

Table 5: List of in-depth interviewees

Organizational Type	Name	Interviewee
Universities	1. Chulalongkorn University	Head of Mechanical Engineering Department
	2. King Mongkut's Institute of Technology North Bangkok	Head of Mechanical and Aerospace Engineering Department
	3. King Mongkut's Institute of Technology Ladkrabang	Head of Mechanical Engineering Department
	4. King Mongkut's University of Technology Thonburi	Vice President
	5. Rajamangala University of Technology Thanyaburi	Head of Mechanical Engineering Department
	6. Rajamangala University of	Head of Mechanical Engineering

Organizational Type	Name	Interviewee
	Technology Phra Nakhon North Bangkon Campus	Department
	7. Mahanakorn University of Technology	Head of Mechanical Engineering Department
	8. Siam University	Head of Automotive Engineering Department
Research Institute	National Metal and Materials Technology Center (MTEC)	Director
Revolving Organizations	1. Thailand Automotive Institute	Director
	2. Thai Auto-Parts Manufacturers Association	Director of Cluster/SME Project
	3. Thailand's Society of Automotive Engineer (TSAE)	President
	4. Thai Automotive Industry Association	President
Firms		
(1) Auto-Part Producer	Somboon Advance Technology Co., Ltd.	Executive Advisor
(2) Auto-Assemblers	1. Thairung Union Car Public Co., Ltd.	General Manager
	2. Toyota Motor Thailand Co., Ltd.	Senior Vice President Technical Division

3.5.5 Data processing

The mail survey was coded and analysed through employment of descriptive statistics (distribution in percentages) and shown by graphs. For the data from in-depth interview, the interviews were transcribed (as in Appendix G) and analyzed concentrating on the implication of the linkages among academia, industry, and government that are to promote industrial competitiveness and innovation. The results were then shown by tables of summary.

3.6 Limitations

- Because of economic recession in late 1990s, some automotive part's businesses were closed down to 100 firms in 2007 as the time this study was conducted. From 100 firms, some firms are practically merged, some firms are not willing to give information, and some others do not give any response. Therefore, this study only obtained 50 data sets of questionnaires from participating automotive firms. However, it may not threaten the generalisability of research findings due to the representation of participating firms' size, economic value and ownership.
- Many companies I contacted were not interested in in-depth interview and even completing questionnaire because they do not have policy to disclose their information.
- With interviews and survey, perception and interpretation of informants and researcher might play some roles. This does not make information they give invalid; it means either they interpret what they sense or I interpret what they say in those terms.

3.7 Ethical Consideration

Ethics is generally a set of 'rules, principles and conventions' that outline socially acceptable behaviours and social members' actions (Anderson, 1990, p17). Regarding social research, ethical issues are then needed to be considered at every stages of

research conduct to minimize potential harms of participants while the quality of research is maximized (Cohen & Manion, 1994; Anderson, 1990)

McNamara (1994) identifies five ethical concerns to be considered when conducting social research. These guidelines deal with the issues of informed consent, voluntary participation; respect for privacy, safeguarding anonymity and confidentiality, and accuracy of report and result. Each guideline is then addressed and be considered in my study as of the following.

1) Informed Consent

Informed consent from the informants is an ethical requirement for any social research. It requires the study to provide research informants a detailed clarification of the research's purposes, ensuring that they are informed of the details of research including audiences of output, sponsor of the study, and voluntary consent facilitation (McNamara, Ibid).

In my survey, the purpose of the study was provided in the cover email explained that the results of the study would be used in a dissertation as partial fulfilment for a Doctoral degree and might be used by policy makers and involving parties to understand such dynamics and further improve such relationship to enhance industrial competitiveness. With the interviews, I explained informant details and purposes of my study and ensured that they understand before proceeding interview.

2) Voluntary Participation

Researcher must ensure that participation in the study is on voluntary basis. However, voluntary participation sometimes conflicts with the demand for high response rate since low return rate can be seen as response bias (McNamara, Ibid).

To encourage a high response rate with voluntary participation, I made at least four contacts per a potential informant. First, the researcher contacted targeted entities by calling and emailing to determine the appropriate contact persons and to confirm contact information. Second, letters explaining details and purposes of

the study were sent to all samples. Third, a week after the letters were mailed, questionnaire packages were sent or appointments for interview were made. Fourth, a “thank you/reminder” letter was mailed within 10 days after the mailing of full questionnaires or an interview was completed. Fifth, calling and email contact was sent three weeks after, for those who had not responded, to remind respondents to complete the mail survey.

3) Respect for Privacy

Literature on research methodology recognizes the essence for researchers to respect privacy of participants and assert that this should be complied at all costs to protect them against unwanted interference and potential threats (McNamara, Ibid; Cohen & Manion, 2004; Bryman, 2004). This respect for privacy may also include avoidance of participants’ embarrassment and discomfort about study and question.

With pre-tests of both survey questions and interview questions, this study did not include sensitive questions that could cause participants embarrassment or discomfort. Harms that could arise in data analysis or in the survey results are prevented through the safeguard of anonymity and confidentiality as they are discussed below.

4) Safeguarding the Anonymity of Participants and the Confidentiality of Data

To protect the participants’ privacy, the most important practices concern anonymity of participants (i.e. all information made to public would contain no identification of participant on the basis of response) and confidentiality of data (i.e. it deals with the deletion of identifiers from the data publicly disseminated) (McNamara, Ibid; Pulmer, 2001).

In this study, the cover email clearly explained participants that the survey is confidential in regards to responses and the reporting of results. Participant identification was kept confidential and was only used in determining who had not responded for follow-up purposes. For interviews, the participants were asked if information could be disclosed through the name of their organization. I also

showed them their relevant information/data that might appear in the report for accuracy and privacy check.

5) Accuracy of report and results

The fifth ethical guideline, as described by McNamara (Ibid), is to accurately report both the research methods and the results of the study. Because advancements in academic fields involve dignity, honesty and openness; I assume the responsibility to report data and result that I perceive as the most accurate. The researcher is to report problems and weaknesses experienced in the study, as well as the positive aspects of the study.

Chapter 4

Results and Findings

This chapter presents the analysis of secondary data and the field survey findings concerning the relationship between universities and industry in the knowledge economy, as represented in Thailand's automotive cluster. The findings and data analysis are provided in 6 parts:

- Thai automotive industry;
- Survey analysis of Thai auto-part producers;
- In-depth analysis of the Thai automotive industry;
- In-depth analysis of Thai universities and industry linkage;
- In-depth analysis of Thai research institutes and revolving organizations;
- Conclusion of Findings.

4.1 Thai automotive industry

4.1.1 Development of Thai automotive industry

The automotive industry in Thailand has emerged through the import substitution policy adopted in 1960 when the government launched the Industrial Promotion Act providing incentives for foreign investors to establish automobile plants in Thailand. As a result of the act, the Anglo-Thai Motor Company was established as the first automotive assembly plant in 1961, while Toyota Motor Thailand and Nissan Motor were established in the early 1960s, and many companies have since followed during the subsequent forty years in response to the promotional and protective policy of the Thai government. An example of such policy is that the Thai government, in 1971, required automotive companies to convert their product assembling from Semi-Knock Down (SKD) to Complete Knock-Down (CKD). The history of the automotive industry since western and Japanese auto-related companies entered Thailand is summarised as in Figure 9.

1998-1999	Abolished the local content requirement policy.	1998	BMW Thailand Manufacturing established.	1997	GKN (UK) Parts Suppliers		Auto Manufacturers	1997	Thai Automotive Parts Siam Co. Interior (NHK Spring) was established.
1962	BOI established.	1999	Thai Yarnon started licensed production of VW cars.	1998	Visteon Thailand (US)	1962	Siam Motors & Nissan commenced production and sales.	1988	Thai Visteon Electric Co. was established.
					TRW (US)				
				1999	Johnson Controls (US)	1964	Toyota Motor Thailand commenced production and sales.		
2000	Normal high local content policy to correspond with the trade committee (ADC).	2000	GM Thailand commenced production.	2000	Delphi Automotive Systems (US)	1966	Isuzu Motors Thailand was established.		
		2000	BMW commenced production.	2001	Delphi's new factory started operating				
1971	Motorcycle-assembling parts and motorcycle-assembler factories established.	2001	Scania Siam commenced production.	2002	Tenneco Automotive (US)	2004	Toyota IMV commenced production. Annual capacity was increased from 200,000 units to 300,000 units.		
1972	Ministry of Industry (MI) announced car-assembly policy.					1973	Siam Nissan Automobile was established.	1972	Denso Thailand was established.
1977	MI announced motorcycle policy.	1976	Volvo established a					1974	Dyna Metal Co. Ltd. commenced operation.
1978	MI announced a standard mix on percentage of local contents required for passenger-car assembling.		Manufacturing and sales subsidiary.						
1979	MI announced a standard mix on percentage of local contents required for truck and bus assembling.					1979	Toyota Auto Body commenced production of pressed parts.		
1980-1986	MI announced the list of required local contents for passenger-car and pick-up assembling.					1984	Honda commenced licensed production.	1981	Thai Stanley Electric commenced operation. Thai Steel Cable (Japan Cable System) commenced operation.
						1987	Isuzu Engine Manufacturing was established.	1985	EXEDY Friction Material was established.
						1987	MMC Sittpol was established.	1986	Thai Koito Co. Ltd. commenced operation
						1989	Siam Toyota Manufacturing commenced production of engine units.		
1989	MI announced a new passenger-car policy.			1989	Freudenberg (Germany)	1989	Isuzu Die Making commenced production of pressed parts.		
1990	MI announced a new pick-up truck policy.			1992	Hayes Lemmerz International (US)	1992	Honda Automobile Thailand commenced production.	1990	Jibuhin (Thailand) Co. Ltd. was established.
1994	Registration of car-assembly plant.			1994	Dana (US)	1992	Mazda Engineering commenced production.	1993	Thai Summit Mitsuba Electric Mfg. commenced operation.
				1995	Federal_Mogul (Germany)	1993	Toyota Leasing, auto loan provider, was established.	1995	Toyota Gosei (Thailand) commenced operation. Thai Nippon Seiki was established. Thai Seat Belt Co. Ltd. (Tokai Rika) commenced operation.
		1998	Auto Alliance, a JV between Ford and Mazda, commenced production.	1996	Autoliv (Sweden)	1996	Siam Nissan Casting was established.	1996	Siam Kayaba Co. Ltd. commenced operation. Siam Calsonic Co. Ltd. commenced operation.
					Arvin Meritor (US)				
					Robert Bosch (Germany)				

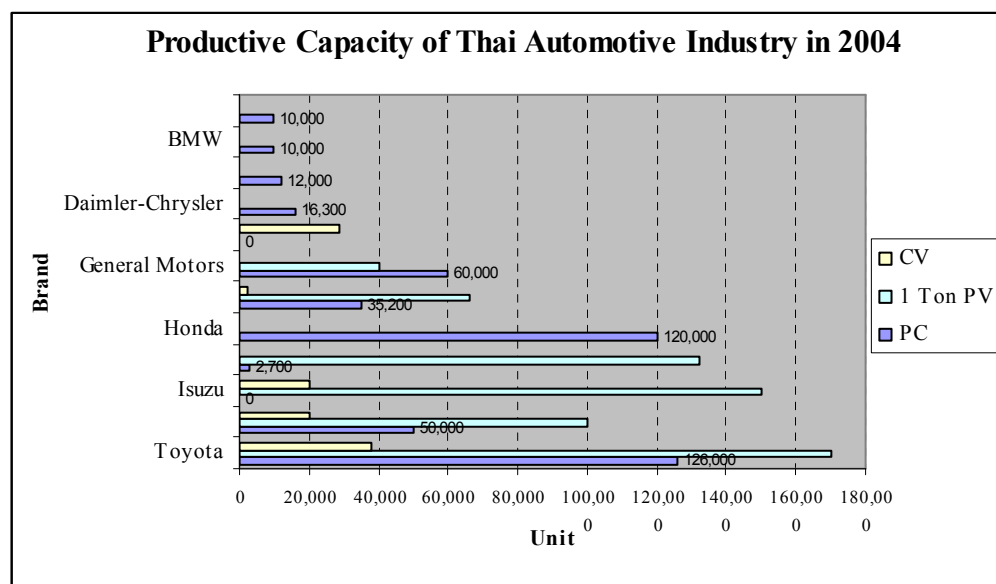
4.1.2 Structure of the Thai automotive industry

1) Auto assemblers

After more than 40 years of a Thai automotive industry, the number of assembly plants has increased to 12 (Japanese assemblers accounting for 50%). These auto assemblers represent various global brands (Chiasakul, 2004):

- (1) European brands: BMW, Volvo, Daimler, Volkswagen, Citron, and Peugeot;
- (2) US brands: GM, Chrysler, and Ford;
- (3) Japanese brands: Toyota, Honda, Isuzu, Nissan, Mitsubishi, Hino, and Mazda.

The Thailand production capacity is approximately 1.2 million units per year. The one-ton pick-up vehicles are the national product champion accounting for 54.5% of total production (Figure 10).



Note: PC - Passenger Car, CV - Commercial Vehicle, PV - Pick-up Vehicle

Source: Thailand Automotive Industry Association and Chiasakul, S., 2004

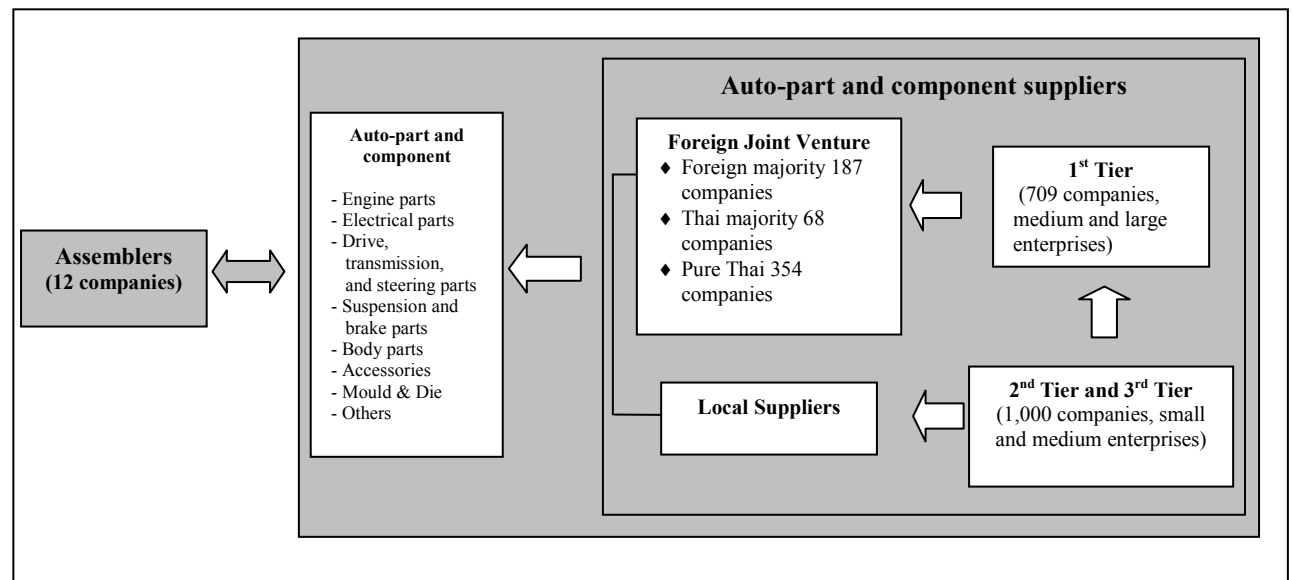
Figure 10: Productive capacity of Thai automotive industry in 2004

2) Parts and components industry

The major export market for auto parts are Japan, US, Malaysia, South Africa, and Indonesia. The most important exported automotive items are Original Equipment Manufacturer (OEM) parts, engines, and spare parts.

3) Structure of auto-assemblers and auto-part component suppliers

The structure of Thai automotive industry embodies 2 components, auto-assemblers and auto-part component suppliers, which are also classified by relative-tier, as shown in Figure 11.



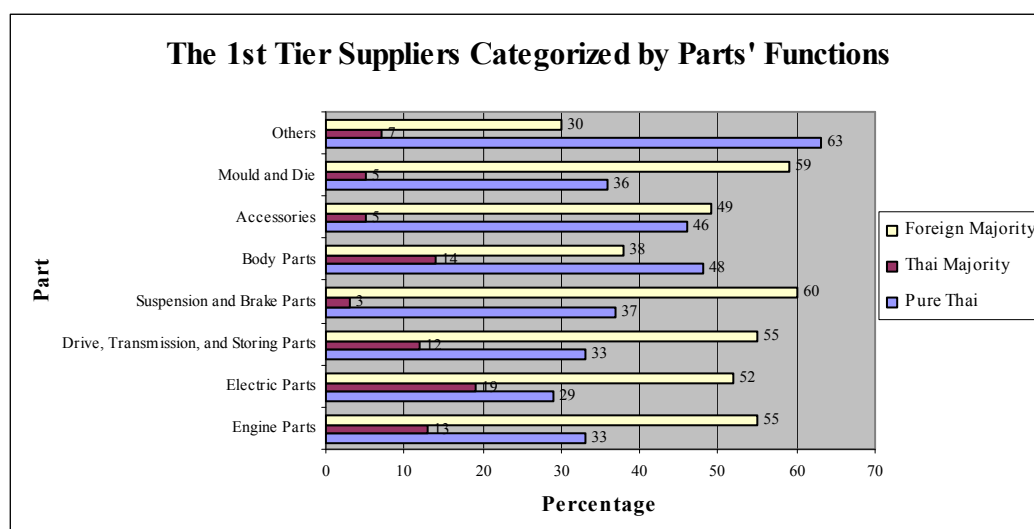
Source: Thailand Automotive Industry Association and Chiasakul, 2004

Figure 11: Structure of relationship between auto-assemblers and auto-part and component suppliers

The 1st tier of the parts and component industry comprises 709 companies with 40% of these having majority foreign company ownership, 10% majority Thai ownership, and 50% being pure Thai companies. However, the pure Thai companies' value was limited to only 8-10% of the total, reflecting the lower technical capacity possessed by Thai subcontractors. The study by Chiasakul (2004), discusses that local subcontractors are at a commercially disadvantageous position. Subcontractors are commercially controlled by assemblers, particularly in the case of exclusive

subcontracts. Chaisakul explains that such an asymmetric relationship makes auto-assembler's parent companies interfere with details of production costs and demand cost cuts, which creates competition among subcontractors. Many subcontractors claim that the relationship between subcontractors and auto assemblers is unfair.

The 2nd tier and 3rd tier suppliers are mostly Thai companies, with the total membership of 1,000 companies. Most of them are family-owned with inward-looking perspectives, even if they produce quality components. They feel that there is an enormous pressure from the local assemblers which have called for price reductions. The 1st tier suppliers, categorized by parts' functions and nationality of equity owners, are those foreign-owned companies engaged in engine and safety parts in the local contents' requirement (Figure 12).



Source: Thailand Automotive Industry Association and Chiasakul (2004)

Figure 12: The 1st tier suppliers categorized by parts' functions

4) Location

The Thai government provided investment promotional privileges and incentives for relocation, which encouraged manufacturers to establish production and procurement systems that have formed the automotive networks at the existing locations. These areas are the bases of car production, or cluster of automotive industry. An area in Samutprakarn (the sample for this study), with the production network of leading Japanese auto assemblers and firms concerning logistics and parts is so called the "Automotive Industry Cluster of Thailand." It is the first, largest and most important

cluster of the automotive industry in the region. However, after the economic crisis in 1997, the newly established automotive assemblers have invested in the new industrial estates in the Eastern provinces of Thailand through governmental incentives (shown in Table 7).

5) Employment

Thai Automotive Institute reported in 2003-2004 that the automotive industry (automotive assembly plants, parts and component industry, motorcycle assembler, and other related industries) employed 113,512 workers. Small and medium sized enterprises accounted for 36.2% of total employment (Chiasakul, 2004). The employment classified by size and part component was as it follows while Table 6 shows distribution among provinces:

• Large-scaled factories	52,319	workers
- Auto-assembly plants	17,119	workers
- Auto-parts and component	21,668	workers
- Motorcycle assembly plants	8,402	workers
- Modify-plants	7,297	workers
• Small-to-medium factories	41,606	workers
- Auto-parts and component	11,344	workers
- Other factories	20,262	workers
• Plastic-part for automobile	2,663	workers
• Inner-tube for auto-tyre	5,986	workers
• Mould and die makers	10,938	workers
Total	113,512	workers

Table 6: Location of automotive assembly plants and automotive part and component suppliers in Thailand

Type	Chachoengsao	Chonburi	Bangkok	Rayong	Samutprakarn	Samutsakorn	Pathumthani
Auto-assemblers	- Toyota Motor Thailand	- MMC Sittiphol (Mitsubishi)	- Bangchan General Assembly - Hino Motors (Thailand)	- Auto Alliance (Thailand) - GM (Thailand)	- Toyota Motor Thailand - Isuzu Motors - Siam Nissan Automotive - Siam V.M.C. Automobile - Thai Auto Work	- Thai Rung Union Car - Thai Swedish (Volvo) - Thonburi Auto Assembly	
Auto-part and component		Total Suppliers=55 Body Parts = 25% Engine Parts = 22% Drive Transmission & Steering Parts = 15% Electrical Parts = 9% Accessories = 5% Suspension & brake Parts =4% Mould & Die = 4% Others = 16%	Total Suppliers=232 Body Parts = 9% Engine Parts = 6% Electrical Parts = 6% Drive Transmission = 6% Steering Parts = 6% Accessories = 6%	Total Suppliers=41 Body Parts = 24% Engine Parts = 15% Drive Transmission & Steering Parts = 15% Suspension & Brake Parts =12% Electrical Parts = 10% Accessories = 7% Mould & Die = 2% Others = 15%	Total Suppliers=158 (at the time of study; total = 100) Body Parts = 22% Electrical Parts = 15% Engine Parts = 8% Drive Transmission & Steering Parts = 8% Suspension & Brake Parts = 5% Mould & Die = 4%		Total Suppliers=39 Body Parts = 18% Engine Parts = 13% Electrical Parts = 13% Suspension Parts & Brake Parts =10% Drive Transmission & Steering Parts = 8% Accessories = 8% Others = 31%

					Accessories = 3%		
					Others = 3%		

Source: Thai Auto-Part Association.

4.1.3 Current situation of Thai automotive industry

Thailand has the largest automotive assembling capacity and possibly the highest quality parts manufacturing capability in the region. As the Thai automotive industry has matured, the industry has grown from being an import-substitution to become an export-oriented industry. At present, the automotive industry is Thailand's third largest industry, employing an estimated total workforce of about 100,000-300,000 employees and producing more than one million cars and trucks per year (Office of Industrial Economics, 2002; Chiasakul, 2004; TSAE, 2006).

In the current market, locally assembled vehicles account for 95% of the domestic market. The most popular type of automobile in the Thai market is the one-ton pick up truck. As in many other ASEAN countries, Japanese-made automobiles have dominated the local auto market, with nearly 90% market share. The six best selling automobile brands in Thailand are Toyota, Isuzu, Nissan, Mitsubishi, Honda and Mazda respectively.

Most existing vehicle manufacturers have increased their investments to fortify their business position in the Thai market. In recent years, Daimler Chrysler (Mercedes-Benz) and BMW have also increased their investment to gain complete control of local manufacturing and marketing operations. Moreover, some vehicle brand owners that have no local assembling operations are expected to officially introduce their assembling plant in the country to take advantage of the CKD duty incentive scheme (Thailand's Ministry of Industry: Office of Industrial Economics, 2002).

1) Domestic production and joint venture

The Thai auto part industry incorporates approximately 600 Original Equipment Manufacturers (OEMs) and Replacement Equipment Manufacturers (REMs) combined. Since around 80% of the country's overall auto assembling capacity belongs to Japanese makers, most of these OEMs are mainly members of Japanese *keiretsu*¹ groups

¹ *Keiretsu* is a set of companies with interlocking business relationships and shareholdings. It is a type of business group.

supplying their own customer base. These companies can be categorized into three groups: a member of the Japanese family of companies, a joint venture with Japanese technology owners, and a company having technical assistance or licensing agreements with Japanese firms. However, in recent years, many new investments from non-Japanese 1st tier suppliers entered the country. The majority of pure Thai (PT) companies are in the 2nd tier, 3rd tier and in the REM business (Office of Industrial Economics, 2002).

According to the Japanese Automobile Manufacturers Association (JAMA), the quality of automotive parts in Thailand is rated the best among ASEAN countries. The local part manufacturers supply approximately 80% of all the parts used for the assembly of pickup trucks, approximately 55% for passenger cars and nearly 100% for motorcycles. Locally produced or assembled parts include engines, suspension control and spring, axles, hubs, propeller shaft, brakes, clutches, steering systems, body parts, electronic parts, air conditioning, tyres, wheels, internal and external trim components and glass. In recent years, the number of part manufacturers for non-Japanese assemblers has increased considerably as a result of Auto Alliance (Ford)'s and General Motors' establishment in the Thai automotive industry. The American assemblers have brought a number of their own 1st tier suppliers to Thailand.

2) Technology Transfer and Development

Among Joint Venture (JV) companies, technology and new management strategies can be efficiently transferred from parent company to the JV Company. The supports are normally financial support, high technology machines, research activities and development programmes to continuously improve products and production quality. Moreover, Joint Venture companies can take advantage of receiving very low interest funding from their parent company. However, management problems among partners in some cases might have led to a problem of high-costs due to the high expenditure on management (Thailand's Ministry of Industry, Office of Industrial Economics, 2002).

Some local part manufacturers have technical assistance agreement (TA) with foreign companies on a product-by-product basis. This technical assistance does not usually cover funding or management issues. While TA firms could develop their own

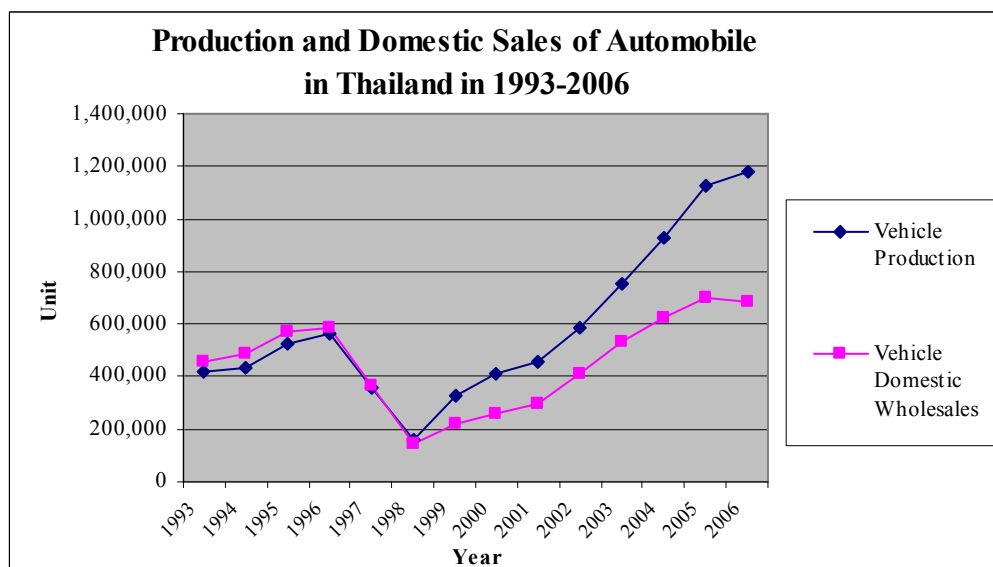
effective/efficient management, management costs for local companies are often less than those of JV companies.

For Pure Thai (PT) companies, production technology and management style originate within the organization without any support from foreign companies. Due to the financial crisis and inadequate technical capability, many of the PT companies have been transferred into JV and TA companies. Some of the remaining PT companies have opted for foreign technical support for helping them improve their technical know-how. The PT companies are usually appropriate for manufacturing parts in which high technology is not required. Costs in these companies are relatively low due to the less-expensive production technology which accommodates cheaper machines and lower salaries for workers. Although most of the PT companies make good quality products, some may not meet global standards because of outdated technology and management problems. Nowadays, PT companies need to improve their technical and research capabilities to meet the global market requirements, and they should also catch up with the information technology trend for their competitiveness.

3) Production, Import, and Export of Thai automotive industry (especially vehicle and parts)

- **Production and domestic demand**

The production of Thai automobile has increased rapidly since the latter half of the 1980s; the average growth of production during 1993-1996 was 9.53%, attributed to liberalization policy which lowered the prices of automobiles in the local market. The production of Thai automobiles reached its highest level in 2006, when Thailand exported almost 500,000 units of Complete Build Up cars (CBU). Many auto assemblers have leveraged their production network to export more cars in order to compensate for their declined share of domestic market (Figure 13).



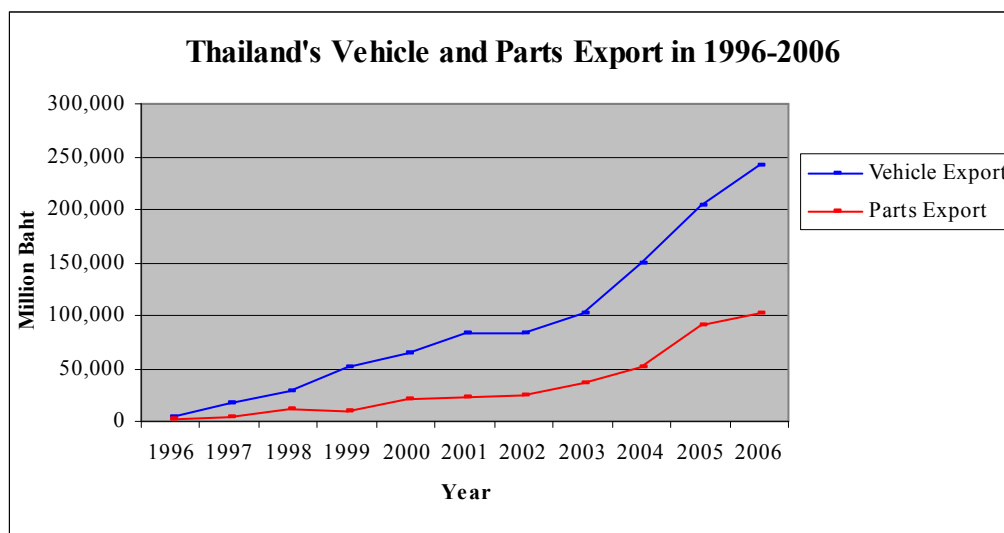
Source: Thai Automotive Industry Association and the Federation of Thai Industries,
Automotive Industry Group

Figure 13: Production and domestic sales of automobile in Thailand,
1993-2006

- **Vehicle and parts export**

The export value of CBU cars in 2006 was approximately 177,692 million baht, an increase of 18.7% on the previous year. Major markets during 2001-2006 were Australia, Indonesia, Saudi Arabia, and UK.

Auto-parts were mostly exported to Japan, Malaysia, Indonesia, US, South Africa, Cambodia, Laos, and the Philippines. The export value in 2006 was approximately 102,166 million baht, an increase of 12% on the previous year (Figure 14).



Source: Thai Automotive Industry Association

Figure 14: Thailand's vehicle and parts export, 1996-2006

- **Imports**

The import value of CBU in 2006 was approximately 19,353 million baht, decreasing 20.9% from the previous year. Major sources were Japan, Germany, Indonesia, the Philippines and the UK, while passenger cars and trucks' sources are Japan, Germany, Indonesia, Portugal, and Spain (Thailand Automotive Institute, 2006).

The import value of parts and components for vehicles was 111,476 million baht, a 10.7% decrease from the previous year. Major origins were Japan, Germany, Sweden, USA, Malaysia, Taiwan, South Korea and UK (Table 7).

Table 7: Thailand's imports of parts and component of vehicle

List	2004	2005	2006
Vehicle parts	111,242.93	117,197.69	103,022.53
Vehicle components	5,770.19	7,667.93	8,453.51
Total	117,013.12	124,865.62	111,476.04

Source: Thailand's Department of Trade Negotiations, Trade and Economic Centre,

Data from Thailand's Customs Department

4) The global automotive industry

The auto industry is often thought of as one of the most internationalized industries. Its products have spread and become traded around the world, while it is dominated by a small number of companies with worldwide recognition. However, in certain respects, the industry is more regional than global, in spite of the globalizing trends evidenced in the 1990s.

One feature of the auto industry in the 1990s was the way in which leading vehicle manufacturers extended their operations in developing countries. For the global producers, rapidly growing markets in developing countries were meant to provide opportunities for spreading vehicle development costs; for establishing cheap production sites for the production of selected vehicles and components; and for accessing new markets for higher-value-end vehicles which have been produced in the Triad economies (US and Canada, Japan, and Western Europe). The extent to which leading firms have expanded their production capacity in developing countries is shown in Table 8 and Table 9 (UNIDO, 2003: 5).

Table 8: Main light-vehicle assembly plant investment in emerging markets by Triad automakers, early 1990s

Country	GM	Ford	VW Group	Daimler/Chrysler	Fiat	Renault	PSA Group	Toyota	Nissan	Honda
Mexico	X ^a	X	X	X					X	
Argentina		X	X			X	X			
Brazil	X	X	XX		X					
Malaysia								X	X	
Thailand								X	X	X
Indonesia								X		X
Czech/Slovak			X							
Poland	X				X	X				
Hungary										
India										
China			X	X			X			

Source: International Finance Corporation (1994), p. 14, amended with author's own calculations cited in UNIDO, 2003: 7

Note: 1.X^a = Plant operational by early 1990s. XX = Two assembly plants

2. "light-vehicle" means small car

Table 9: Main light-vehicle assembly plant investment in emerging markets by Triad automakers, late 1990s

Country	GM	Ford	Daimler/ Chrysler	VW Group	Fiat	Renault	PSA Group	Toyota	Nissan	Honda
Mexico	X ^a	X	XX ^b	X					X	X
Argentina	X	X	X	X	XX	X	X	X		
Brazil	XX	XX	X	X,XX	X	X	X	X		X
Malaysia							X	X	X	
Thailand	X	X						X	X	X
Indonesia	X							X		X
Czech/Slovak				X		X				
Poland	XX	X			XX					
Hungary	X			X						
India	X	X	X		X			X		X
China	X	X	X	X			X		X	X

Sources: International Finance Corporation (1994), p. 14; Storey (1998); for Brazil, ANFAVEA (1998); for China, Polly (1998); for Central European countries, Havas (2000) cited in UNIDO, 2003:7

Notes: Table 9 and Table 10 should only be taken as a rough guide to global expansion in the vehicle industry. They exclude very small assembly plants. They include some, but not all, assembly plants in which the leading firms only have small minority stakes. Some companies, such as Renault, have expanded significantly in countries not included in the tables. Finally, the tables underestimate expansion in cases where expansion has been achieved predominantly through the enlargement of existing plants. X^a = Plant operational by late 1990s. XX^b = two light-vehicle assembly plants owned by the company in the same country.

The Table 9 and 10 above provide data on light-vehicle assembly plants owned by the top ten vehicle companies in 11 major developing countries. All the assemblers had increased their global coverage as follows:

- 1) Assemblers with plants in emerging markets opened new plants in these same markets in the 1990s;
- 2) North American and European manufacturers opened new plants in Eastern Europe. Smaller assemblers such as Suzuki and Daewoo (not shown in Table 9 and Table 10) also invested in Eastern Europe at this time;
- 3) There was a massive entry of companies into India;
- 4) More companies entered the Chinese market;

- 5) The producers from North America had begun to challenge the dominance of Japanese in the ASEAN markets. There was also a challenge from Korean manufacturers in these markets, which is not shown in the tables;
- 6) Japanese firms entered the Latin American market.

For developing countries, one of the key reasons for promoting the auto industry was to encourage the development of domestic component industries. These would not only create jobs and reduce the effect on the balance of payments of imports of vehicle parts, but also stimulate domestic technological capability more generally through spillover effects. These might be further enhanced if at least part of the domestic component industry was locally owned or took the form of joint ventures between local companies and transnational companies. Many countries (including Thailand) regards the introduction of local assembly plants as the first step in the development of domestic auto industry. Local content requirements are imposed in order to increase local production, even though this frequently involves uneconomical levels of production and higher-priced vehicles.

The global auto industry at the beginning of the 21st century is composed of a number of different segments and capacity requirements as presented below (UNIDO, 2003: 22):

- 1) **Assemblers.** Increasing scale is required to spread costs of vehicle design and branding. Advantages of innovation and design capabilities remain critical as the first movers in new markets can gain critical rents while other companies catch up. Some companies, such as Ford, appear to believe that core competences lie more in branding and finance, and they are outsourcing parts of manufacturing. Others, such as Toyota, maintain an emphasis on manufacturing excellence and competence.
- 2) **Global mega-suppliers.** These firms supply major systems to the assemblers. They are sometimes referred to as "Tier 0.5" suppliers, because they are closer to the assemblers than the first-tier suppliers. These companies need to have global coverage, in order to follow their customers to various locations around the world. They need design and innovation capabilities in order to provide "black-box" solutions for the requirements of

their customers. Black-box solutions are solutions created by the suppliers using their own technology to meet the performance and interface requirements set by assemblers.

- 3) **First-tier suppliers.** These are firms, which directly supply the assemblers. Some of these suppliers have evolved into global mega-suppliers. First-tier suppliers require design and innovation capabilities, but their global reach may be more limited.
- 4) **Second-tier suppliers.** These firms will often work to designs provided by assemblers or global mega-suppliers. They require process-engineering skills in order to meet cost and flexibility requirements. In addition, the ability to meet quality requirements and obtain quality certification (ISO9000 and increasingly QS9000) is essential for remaining in the market. These firms may supply in only one market, but there is some evidence of increasing internationalization of second-tier suppliers.
- 5) **Third-tier suppliers.** These firms supply basic products. In most cases, only rudimentary engineering skills are required. A study by Leite (1997) in skills and training at different parts of the automotive value chain in Brazil showed that skill levels and investments in training were very limited in the third-tier of the component chain. At this part of the chain, firms compete predominantly on price.
- 6) **Aftermarket/Replacement suppliers.** Another important segment of the automotive value chain is the market for replacement parts. This is the sector that many firms in developing countries first moved into, even before local assembly sectors were developed. Nowadays, there is an international trade in aftermarket products. Firms in this section compete predominantly on price. Access to cheaper raw materials and process engineering skills is important. Innovation is not required because designs are copied from the existing components, but reverse engineering capability and competence to translate designs into detailed drawings are important.

The requirements of these different sections are quite distinct. Assemblers and global mega-suppliers need global reach, innovation and design capabilities, as well as considerable financial resources. In the 1st and 2nd tier, global reach is not required, even though there are some tendencies towards internationalization in this sector. The

competences needed in the 3rd tier are much less, but the returns are much lower. Finally, the aftermarket section offers a completely different route to customers. The business is much more fragmented and access is easier. However, this section is very price-competitive.

UNIDO (2003: 43) suggested that competence formation for competitiveness in which locally-owned firms might prosper within the global auto components industry should comprise the following:

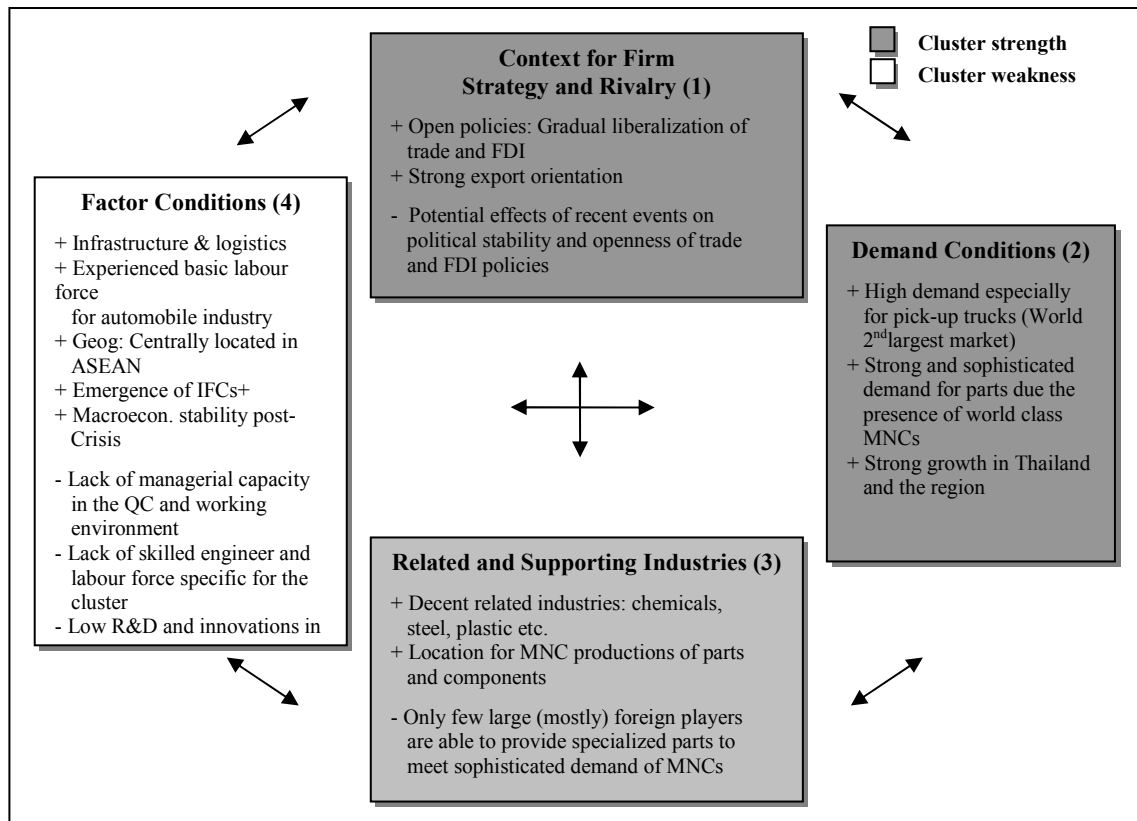
- 1) Second tier component manufacturers should operate within the value chains supplying assemblers in the domestic market;
- 2) Locally-owned firms must ally with transnational companies and supply specialized products for global markets;
- 3) As suppliers to both domestic and international markets, the capacity of locally-owned firms to compete in each of these markets can be influenced by support provided by local and national institutions. The roles of local institutions in facilitating the access of domestic producers to the auto industry value chain are:
 - 3.1) Standards: Entry into the auto industry supply chain increasingly depends upon certification. For second-tier component manufacturers, ISO9000 certification and, increasingly, QS9000 certification are essential. While markets in both the certification process itself and the preparation of firms for certification will tend to emerge, governments can play an important role in developing and controlling these markets;
 - 3.2) Skilled workforce: Firms at all parts in the value chain need skilled workers who are able to enhance process-engineering capabilities. The education and training systems need to supply this workforce. In some sectors, specialist skills in areas such as materials are also required;
 - 3.3) Testing and measurement facilities: The cost of testing and measurement facilities can be high, especially for small firms. Local and national governments are needed to supply specialist laboratory services and create a sound national framework for metrology;
 - 3.4) Market intelligence: Domestic firms' market intelligence is an essential element that serves and supports their participation in trade fairs

encouraging domestic firms to open up new markets. This is particularly important for firms catering for the aftermarket, although it may also be important for opening up new markets for first-tier and second-tier manufacturers.

5) Thailand's automotive cluster

Thailand's automobile cluster emerged during the 1990s and grew rapidly after the Asian Financial Crisis to become one of the leading exporting sectors of the country. Between 1997 and 2004, production increased on average by 81.2 percent per year (Thai Auto Parts Manufacturing Associations, 2006). By 2005, Thailand was the largest production hub of automobiles in ASEAN, exporting about 540,000 cars per year and generating over USD 5 billion of export revenue. Thailand is also currently the second largest exporter of pick-up trucks in the world and has more customized model variations than anywhere in the world. Thailand's market has been dominated by multinational companies (MNCs), especially Japanese manufacturers. In 2005, Toyota, the best-selling brand in Thailand, capturing 40.6 percent of the domestic market while Isuzu and Honda had the second (25.4 percent) and third (7.1 percent) highest market shares (Teoh *et al.*, 2007: 12).

Teoh *et al.* (2007) applied Michael E. Porter's Diamond framework to understand the driving forces behind the development of the Thai automotive cluster. They found that strong local **Demand Conditions (DC)** and continuous improvement in the **Context for firm Strategy and Rivalry (CSR)** have been the key driving forces for the cluster development. Meanwhile, **Related and Supporting Industries (RSI)** and **Factor Conditions (FC)** have been relatively weak (Figure 15).



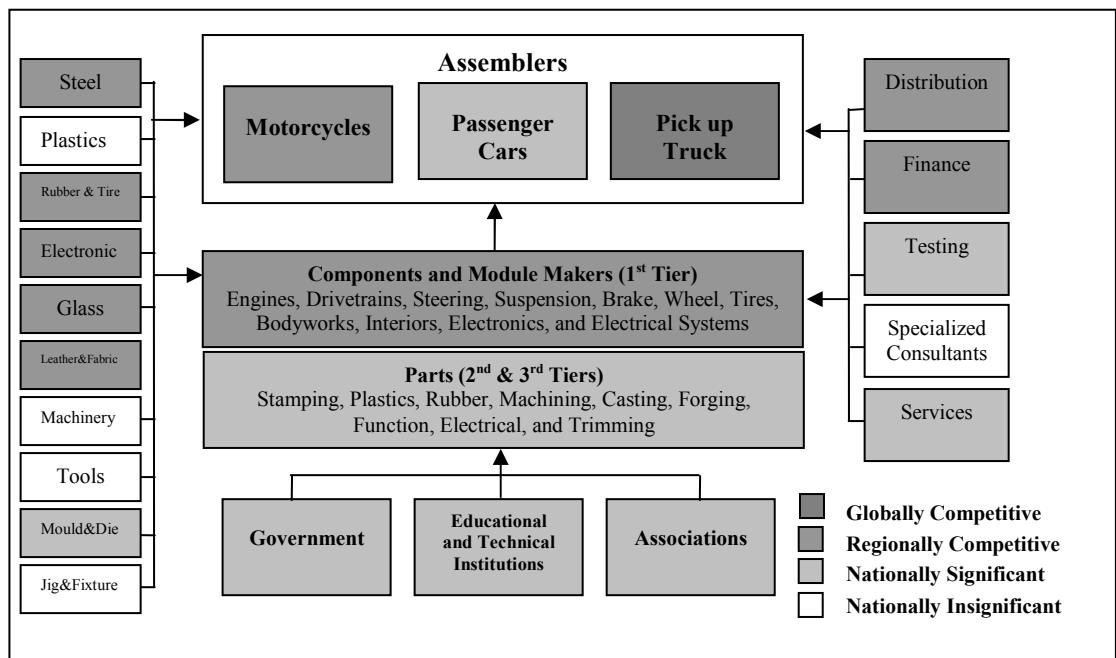
Source: Teoh *et al.*, 2007

Figure 15: Diamond model for the Thai automotive cluster

From Figure 15 above, the combinations of favourable domestic demand conditions (2) for pick-up trucks, some positive factor conditions (4) and an open-trade regime/context (1) attract auto-related foreign direct investment into the country. This has also strengthened the related and supporting industries (3) such as parts manufacturing, while factor conditions (4) need to be improved to enhance competitiveness of the industry.

This study showed that, despite its startling performance, the cluster is still relatively shallow. Most of activities conducted in Thailand remain focused on assembly and less on more technologically sophisticated activities such as R&D and product development or process engineering. While there have been some recent positive signs of improvement (i.e. when Toyota set up their first technical centre in developing countries, the Toyota Technical Centre Asia Pacific, in Thailand in 2003), in general the development of the cluster and shifts towards sophisticated activities have been impeded by weak supporting industries and weak factor conditions (Teoh *et al.*, 2007: 19).

Teoh *et al.* (2007) explained that the weak RSI condition is reflected in the analysis of the Thai automotive cluster map and the competitive strength of each component (Figure 16). Some of the key areas of the cluster remain considered as uncompetitive, such as 2nd and 3rd Tier parts producers. Most of the more sophisticated parts are either imported or produced by foreign firms. Local firms are mostly small and medium scale enterprises serving as 2nd Tier part producers, supplying the raw materials and basic components to the 1st Tier suppliers.



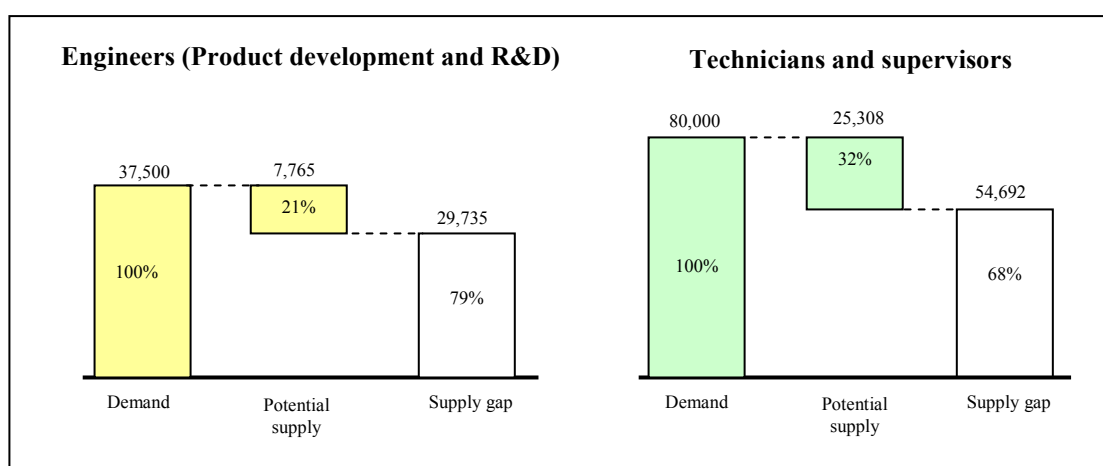
Source: Teoh *et al.*, 2007 and Ketels, 2003.

Figure 16: Thai automotive cluster mapping

A study by the Thai Auto Parts Manufacturing Association (TAPMA) (2002, cited in Teoh *et al.*, 2007) has found that the scarcity of skilled workers, and low management abilities in the area of quality control among local firms are the main reasons why they fail to develop products to meet international standards. These problems also hold back the development of the 1st Tier parts sub-cluster which plays an important role in developing the automotive cluster.

The World Bank's Thailand Investment Climate Survey 2006 suggests that the automotive cluster could gain at least 4.6% in sales if skills shortages are reduced. **The shortage of skilled labour in engineers, technicians and supervisors is also the main constraint that will hinder the future expansion of the Thai automotive cluster to**

higher value added activities such as R&D. According to the Thai Development Research Institute, automotive companies are projecting needs in 2008 of 37,500 engineers and 80,000 supervisors and technicians, yet the supply of such skilled labour will fall short by 70-80%, as seen in Figure 17. There are three major reasons why the current shortage in skills exists. **First**, there is a lack of linkages between universities and automotive companies, such that there is a mismatch between graduates' skills and companies' requirements. For example, in technical colleges, supervisors are trained in repairing instead of in product development. **Second**, there is a weak technical base of labour from the education system. This reflects gaps in the current education policy, which does not have an adequate pipeline to provide sufficient quantities of students trained in engineering to serve industrial needs. **Third**, as discussed in the country analysis section, while foreign workers can be hired to fill some of the skill gaps, the legally required process for hiring foreigners is overly bureaucratic (Teoh *et al.*, 2007).



Source: Thai Development Research Institute, 2005

Figure 17: Estimates for 2008 demand and supply of skilled labour

A study of Thailand's automotive cluster (Toeh *et al*, 2007) has specific recommendations for the country, shown in Table 10.

Table 10: Thailand automotive cluster: detailed country recommendations

Reform Agenda	Specific Recommendations
Regulatory Reform	<ol style="list-style-type: none"> 1. Streamline tax regulations/ reduce tax burden 2. Streamline customs and trade regulations 3. Eliminate price controls, service restrictions 4. Reduce labour regulations (i.e. hiring of local worker) 5. Reduce regulatory uncertainty through clearer guidelines to local agencies/government
Skills Enhancement	<ol style="list-style-type: none"> 1. Establish a vocational workforce training infrastructure 2. Incentives for cluster-based skills upgrading (i.e. matching grants) 3. National ICT literacy programs for the workforce 4. Reform secondary education system : increase completion rates and quality 5. Strengthen English, ICT, science and technology curriculum at all levels 6. Promote R & D in universities and R&D opportunities for graduates
Infrastructure Upgrading	<ol style="list-style-type: none"> 1. Infrastructure development in East and Centre regions 2. Improve contestability in telecommunications sector 3. Develop public ICT infrastructure, support cluster-specific ICT standard setting/promotion of best practices in ICT usage
Improve Linkages to Neighbourhood	<ol style="list-style-type: none"> 1. Implement the Greater Mekong Region Cross Border Transport Agreement : transport infrastructure linkages / alignment of customs procedures 2. Promote common clusters : Product development , R&D, Market development, cross border private investments

Source: Teoh *et al.*, 2007: 30

6) Current view of Thai automotive industry's workforces

At the present, a number of universities have established and run automotive programmes at degree level (TSAE, 2006: 36):

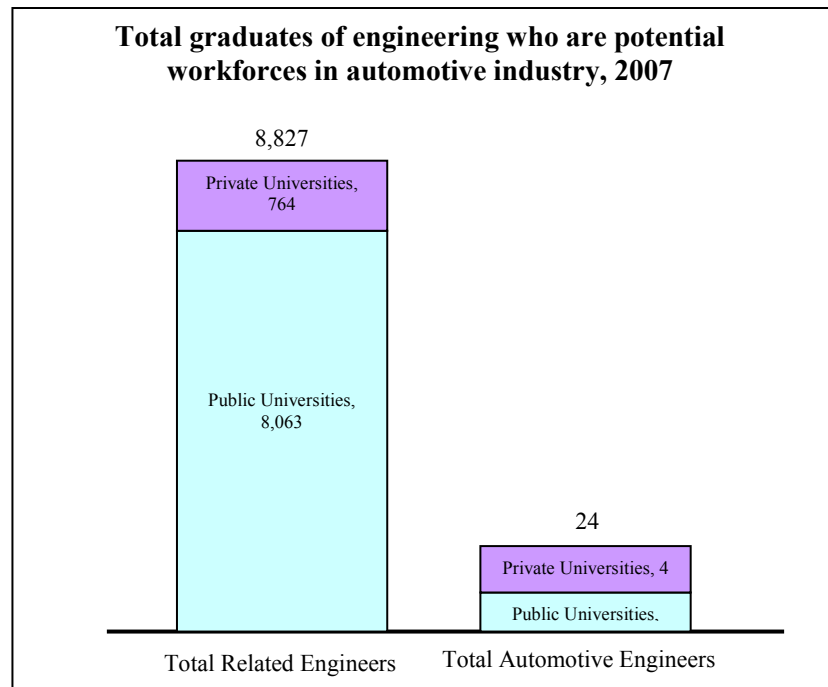
- Chulalongkorn University (both Thai and English programmes);
- Suranaree University of Technology;
- Siam University;

- Sripatum University;
- South-East Asia University;
- Thai-Nichi Institute;
- Asian Institute of Technology.

Besides, some other universities are in the process of establishing automotive curricula (TSAE, 2007: 9).

However, there is only one public university - Chulalongkorn University- and 1 private university - Rangsit University – that have already generated graduates into Thai automotive industry. Chulalongkorn University has generated graduates of automotive engineering for 3 years (15, 20, and 18 people in 2004, 2005, and 2006 respectively), while Rangsit University has generated graduates for 2 years (4 students in 2005 and 15 students in 2006). Meanwhile, other universities have not yet generated automotive engineers since their programmes were only recently established, with graduates still in the pipeline.

Graduates of other related fields could apply to automotive workforce market. These related fields are mechanical, metallurgical, industrial, electrical, computer, and environmental engineering (Figure 18).



Source: Calculated from Thailand's Commission on Higher Education's statistic, Chulalongkorn University's statistics and Rangsit University's statistics

Figure 18: Total graduates of engineering who are potential workforces in automotive industry, 2007

4.1.4 Summary:

The development of the Thai automotive industry had been based on import-substitution policies. At the present, the interest has shifted towards more liberalized policies to correspond with the current global trend. These include loosening tariff barriers, abolishing local content measures, promoting investments and exports, and also cooperating with international communities, such as ASEAN, APEC, and WTO.

The structure of the Thai automotive industry embodies two components, auto-assemblers and auto-part component suppliers, classified by relative-tiers of production. The 1st Tier of the parts and components industry with foreign company majority ownership is estimated at 40%, 10% majority Thai ownership, and 50% pure Thai ownership, while most local firms (mostly small and medium enterprises) serve as 2nd tier, 3rd tier and aftermarket producers

Thailand's auto market has been dominated by Japanese brands. Toyota is the best selling brand in Thailand, taking a domestic market share of 40%, while Isuzu and Honda have the second and third highest market shares, with 25.4% and 7.1% respectively. The major export destinations for Thai automotive production are Australia, Indonesia, Saudi Arabia, UK, Singapore, the Philippines, and Japan. Pick-up trucks, the best selling vehicle type in the domestic market, is the major export items, followed by passenger cars.

In JVs, foreign technology and new management strategies can be transferred efficiently from head-quarter/parent companies. Some local part manufacturers have TAs with foreign companies on a product-by-product basis. PT companies need to improve their technical and research capabilities to meet the global market requirements, and they should catch up with information technology trends to enhance their competitiveness.

A study by Teoh *et al.* applied Michael E. Porter's Diamond framework for Thai automotive competitiveness in the global market and found that a strong local "Demand Condition" and continuous improvement in the "Context for Firm Strategy and Rivalry" have been the key driving forces for the automotive cluster development. The weakness were in "Related and Supporting Industries", and "Factor Condition."

The important problem of Thai automotive competitiveness is the shortage of skilled workers as engineers, technicians, and supervisors. There are three major reasons why the current shortage in skills exists. First, there is a lack of **linkages between universities and automotive companies**, such that there is a mismatch between graduates' skills and companies' requirements. Second, there is a weak technical base in the workforce, arising from the education system. This reflects gaps in the current education policy, which does not have an adequate pipeline to provide sufficient quantities of students trained in engineering. Third, although foreign workers can be hired to fill some of the skill gaps, the legally required process for hiring foreigners is overly bureaucratic.

The study can be summarized by a SWOT analysis of Thai automotive industry shown in Table 11.

Table 11: SWOT analysis of Thai automotive industry

Strength	Weakness	Opportunities	Threats
<ul style="list-style-type: none"> Production capacity available 	<ul style="list-style-type: none"> Shortage of capable human resource and lack of knowledge 	<ul style="list-style-type: none"> Global auto manufactures choose Thailand as regional base 	<ul style="list-style-type: none"> Foreign investment in the region invest more in China
<ul style="list-style-type: none"> Multinational OEMs 	<ul style="list-style-type: none"> Education system is not effective 	<ul style="list-style-type: none"> AFTA enables bigger market 	<ul style="list-style-type: none"> Export from China to ASEAN
<ul style="list-style-type: none"> Various supportive industries in the region 	<ul style="list-style-type: none"> No IT fundamental 	<ul style="list-style-type: none"> Market expansion by trade agreement (FTA) 	<ul style="list-style-type: none"> Great potential for low cost products from China and India
<ul style="list-style-type: none"> Good skilled workers 	<ul style="list-style-type: none"> No R&D infrastructure 	<ul style="list-style-type: none"> Asia Pacific market has appealing future prospects 	<ul style="list-style-type: none"> Global structure excess capacity
<ul style="list-style-type: none"> Expansion of domestic market 	<ul style="list-style-type: none"> Testing laboratories are not sufficient 	<ul style="list-style-type: none"> Potential low cost generic R&D 	
	<ul style="list-style-type: none"> Local firms (mostly SMEs in 2nd and 3rd tier) are considered uncompetitive with capacity to only supply materials and basic components to the 1st tier suppliers 		

The intensity of linkage between producers and users and between producers and suppliers is relatively weak in Thailand. The findings confirm those from the studies of Intarakumnerd, P. and Panthawi (2003) and Arnold (2000), which are as follows:

- Weak cooperation among firms in the same and related industries;
- Low technology spill-over from transnational corporations;
- Weak industry-universities linkage;
- Weak relationship between public research technology organizations and industrial firms;
- Training through governmental institutions fails to upgrade technical expertise of firms' employees to the higher end.

4.2 Survey analysis of Thai auto-part producers

This survey used a sample population of 5 multinational corporations (MNCs), 10 joint ventures companies (JVs), and 35 pure Thai companies (PTs). The findings are as follows:

4.2.1 Fields which firms select to strengthen and enhance their competitiveness

The table below shows that MNCs wish to develop their technology and marketing (each scoring 100%), while most JVs wish to develop their marketing, technology, and human resource (100%, 80%, and 80% respectively). Most PTs pay attention to the development of product and technology (91.4% and 77.1% respectively). From the data, it shows that technology development is the segment that most MNCs, JVs, and PTs are determined to strengthen in order to enhance their competitiveness (Figure 19).

Firms within the sample develop their competitiveness as follows:

- 1) To develop their technology and business solution, MNCs systematically manage their own expertise and knowledge while cooperating with other organizations (100% in each). Most JVs also systematically manage their own expertise and knowledge and cooperate with other organizations (100% and 50% respectively). Most PTs systematically manage their expertise and knowledge and cooperate with other organizations (74.3% and 60%

respectively). The data therefore show that systematically managing their own expertise and knowledge is the most popular practice of MNCs, JVs, and PTs, while cooperating with other organizations is the second most popular method (Figure 20).

- 2) To improve their productivity, MNCs systematically manage their expertise and knowledge and cooperate with other organizations (each with 100%). Most JVs and PTs systematically manage their expertise and knowledge (100% and 82.9%). The data therefore show that systematically managing their own expertise and knowledge is the favoured practice among MNCs, JVs, and PTs (Figure 21);
- 3) To improve their marketing, most MNCs, JVs, and PTs systematically manage their own expertise and knowledge (100%, 100%, and 78.6% respectively) (Figure 22);
- 4) To develop their human resources, MNCs aim to enhance career path/career development for employees and provide regular training (each with 100%). Most JVs and PTs provide regular training (100% and 85.7% respectively). The data therefore show that MNCs, JVs, and PTs prefer to provide regular training for human resource development (Figure 23).

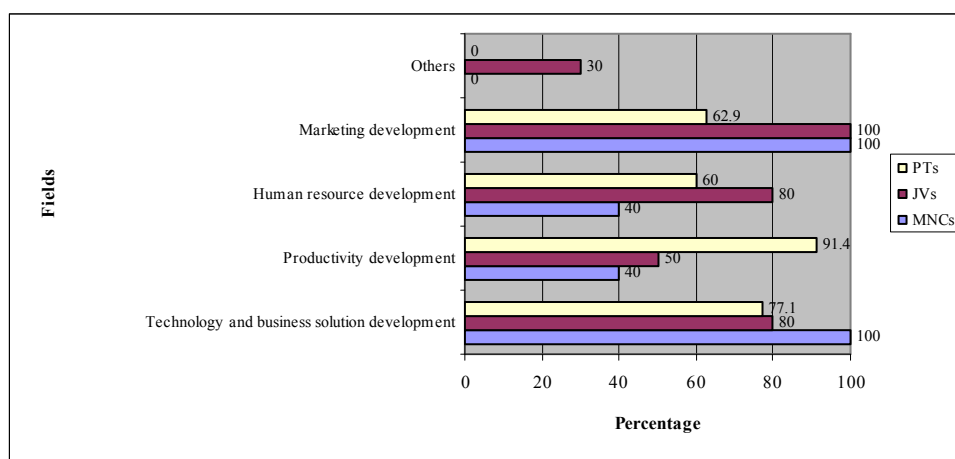


Figure 19: Fields which firms select to strengthen and enhance their Competitiveness (see Appendix G, Table 19)

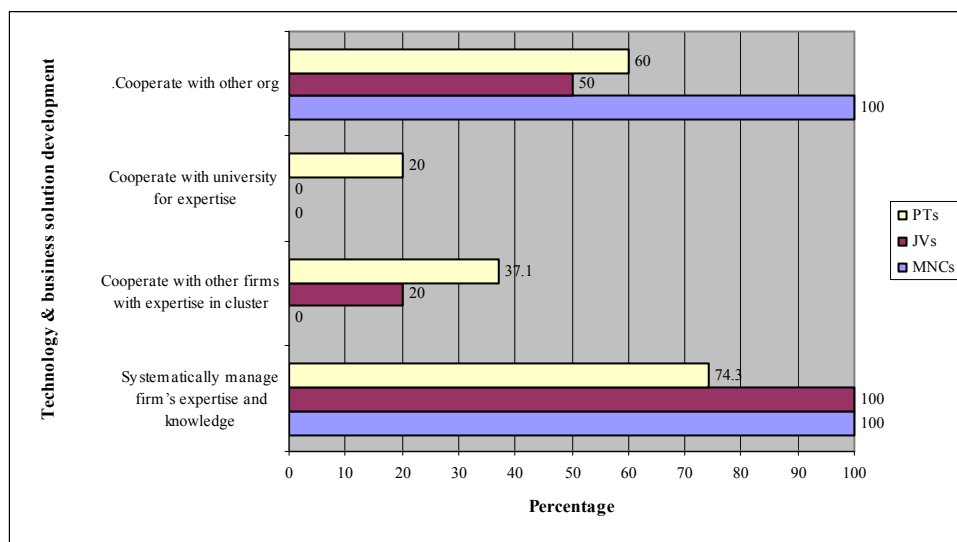


Figure 20: Technology and business solution development (see Appendix G, Table 19)

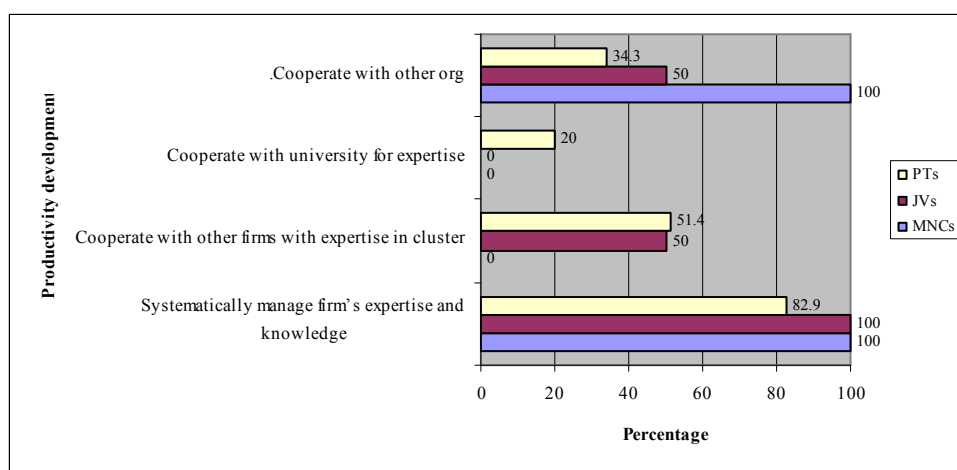


Figure 21: Productivity development (see Appendix H, Table 19)

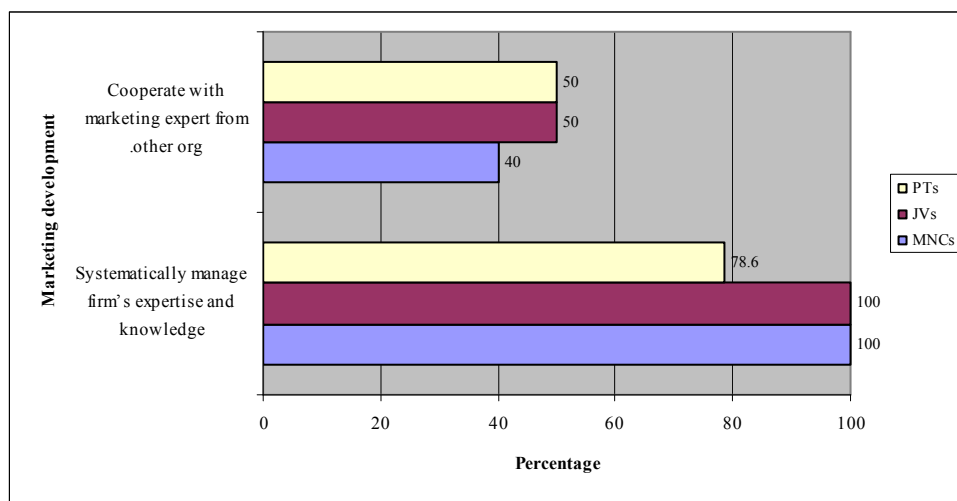


Figure 22: Marketing development (see Appendix G, Table 19)

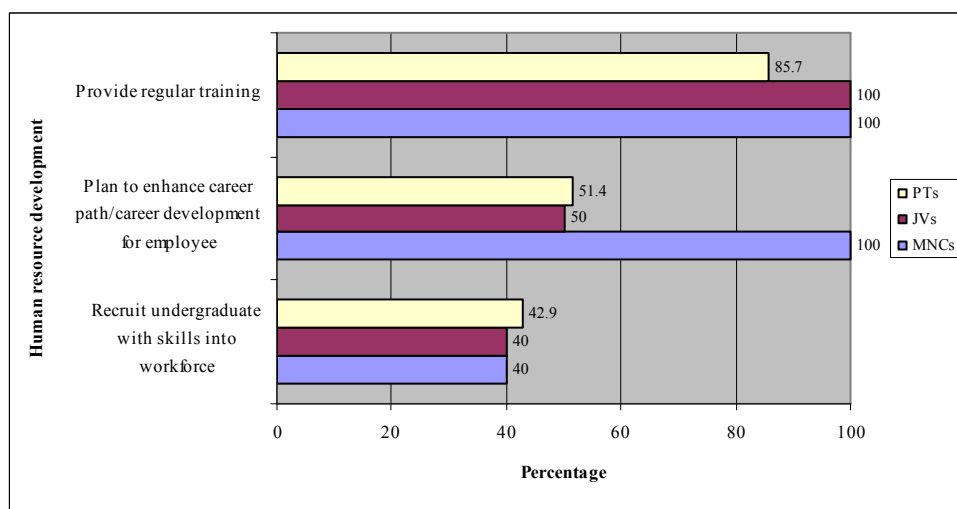


Figure 23: Human resource development (see Appendix G, Table 19)

4.2.2 Cooperation with universities: criteria and university choice

In relation to developing automotive industry and university linkages, 100% of MNCs would select opportunity and capacity for technology transfers as the most important reason for collaborating with universities. Most JVs would choose universities with a high reputation in high technology engineering as the most important criterion (100%). Most PTs would similarly look to the universities' reputation and the quality of graduate training and skills as important reasons for collaborating with universities (83.3% and

73.3% respectively). The data show that all MNCs in the sample would pay attention to universities' opportunity and capacity for technology transfers, while JVs and PTs emphasizes the reputation and prestige of universities in the appropriate fields to determine the cooperation (Figure 24).

With regards to cooperation with universities, most MNCs and JVs in the sample do not specify names of universities with which they might collaborate, while PTs reveal their preferred collaboration mostly with King Mongkut's University of Technology Thonburi and King Mongkut's Institute of Technology North Bangkok (100% and 37.5% respectively). The data show that most of the MNCs, JVs and PTs have not yet developed firm cooperation with a university and there are only a few universities being considered for participation in such collaboration (Figure 25).

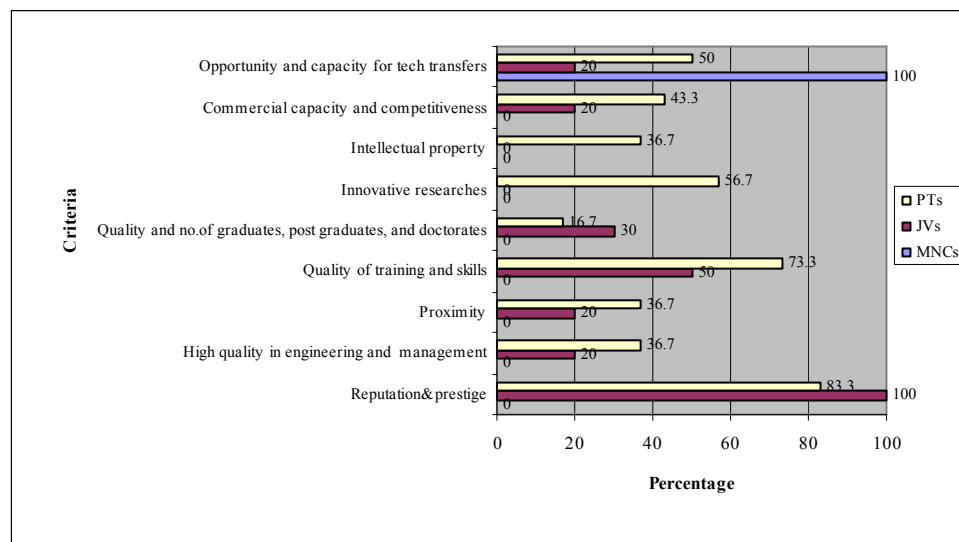


Figure 24: Firms' preferred criteria to select a university to collaborate with (see Appendix G, Table 20)

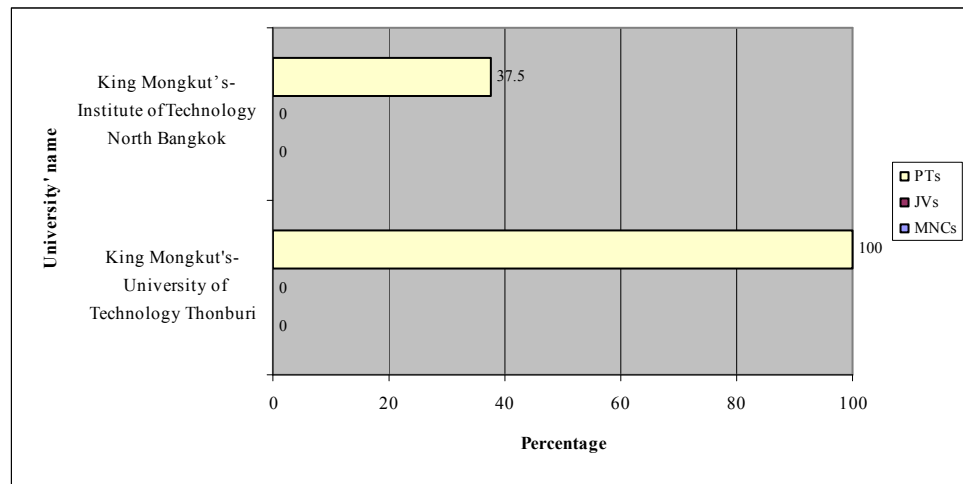


Figure 25: Universities that firms select to collaborate with (see Appendix G, Table 20)

4.2.3 Areas and levels that firms collaborate with universities and other organizations

Universities have the potential to serve automotive industrial needs in several ways: technology development, product development, marketing development, human resource development and personnel training and knowledge worker recruitment. The levels of collaboration in each of these areas are as follows:

- 1) In technology development, universities most commonly serve MNCs' need at the 'little level' (60%), serve JVs' need at the 'least level' (50%), and serve PTs' need at the 'moderate level' (34.3%). The data show that PTs have more cooperation with universities in technology development than MNCs and JVs (Figure 26);
- 2) In product development, MNCs and PTs most commonly reveal a moderate level of cooperation with universities (60% and 57.1% respectively) but JVs mostly cooperate at the least level (50%). MNCs and PTs in the sample therefore have more cooperation with university in product development than JVs (Figure 27);
- 3) In marketing development, universities serve MNCs' need at the most relevant level (100%), serve JVs' need at the least level (50%), and serve PTs' need at the little level (54.3%). From the data, it expresses that MNCs

have more cooperation with universities in marketing development than JVs and PTs (Figure 28);

- 4) In human resource development, it is found that MNCs have the highest level of relevance with universities' cooperation (40%), JVs have the least level of cooperation (80%), and PTs have the moderate level of cooperation (34.3%). From the statistic, it shows that MNCs have more collaboration with universities in human resource development than JVs and PTs (Figure 29);
- 5) In personnel training and knowledge workers' recruitment, universities serve MNCs' need at the little level (80%) and serve JVs and PTs at the moderate level (50% and 34.3% respectively). From the data, it displays that most of JVs and PTs have more collaboration with universities in personnel training and recruitment than MNCs (Figure 30).

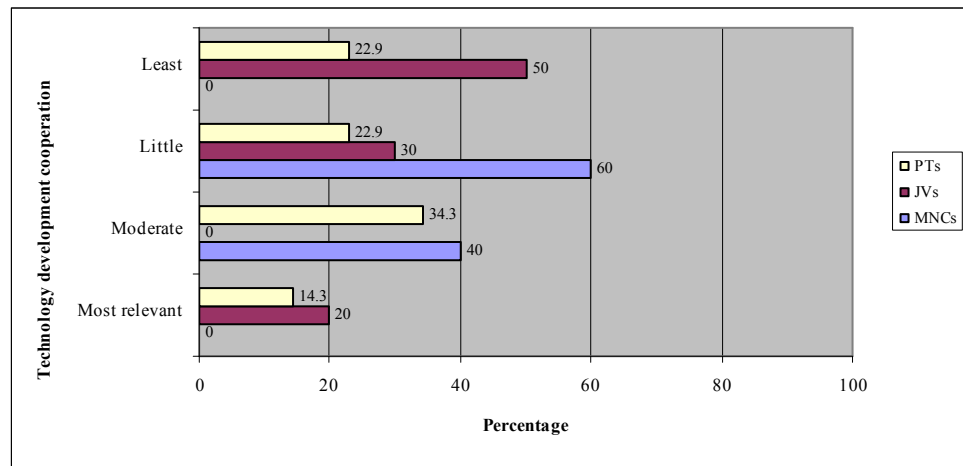


Figure 26: Level of technology development cooperation between firms and universities/other organizations (see Appendix G, Table 21)

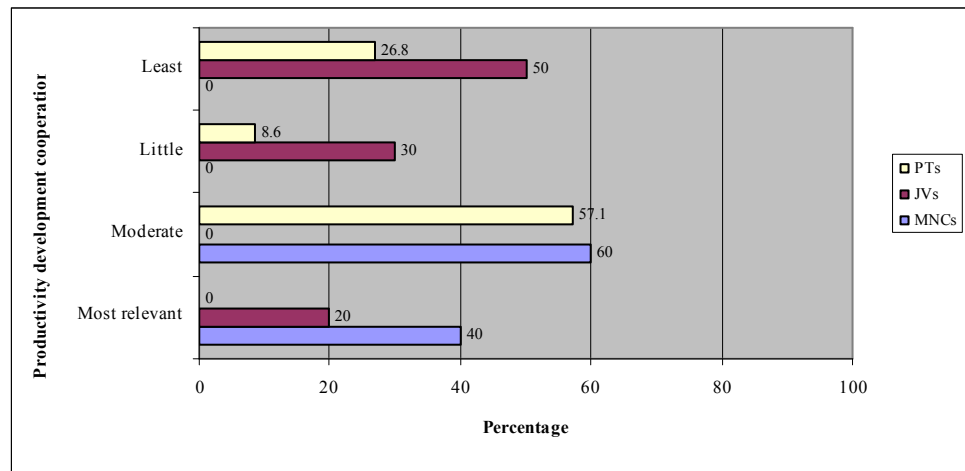


Figure 27: Level of productivity development cooperation between firms and universities/other organizations (see Appendix G, Table 21)

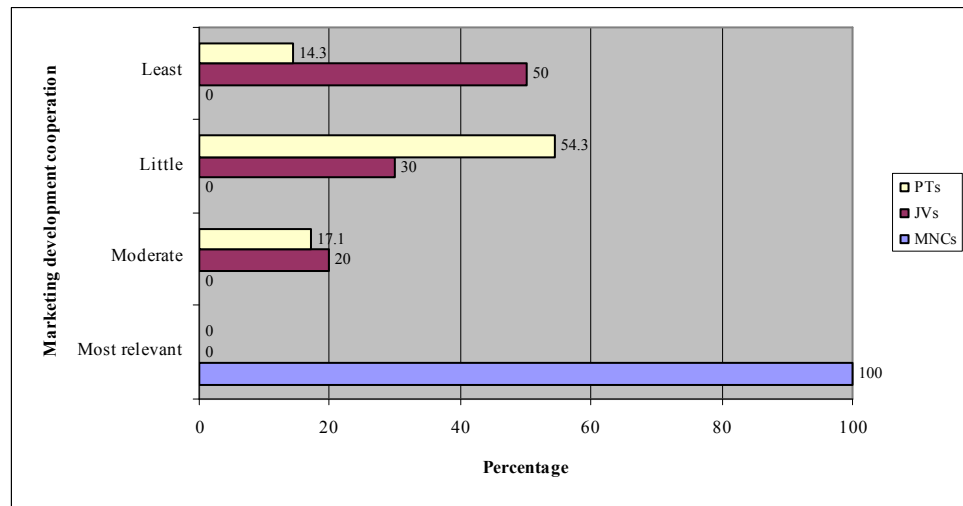


Figure 28: Level of marketing development cooperation between firms and universities/other organizations (see Appendix G, Table 21)

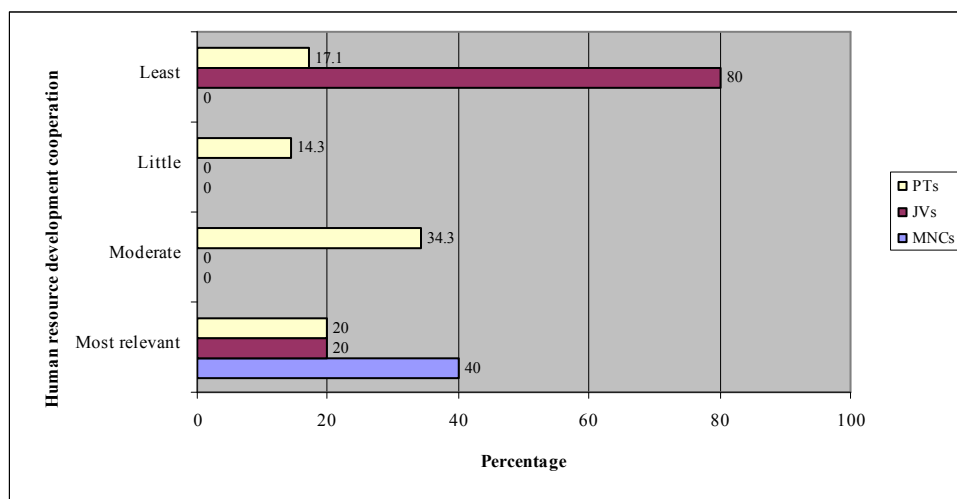


Figure 29: Level of human resource development cooperation between firms and universities/other organizations (see Appendix G, Table 21)

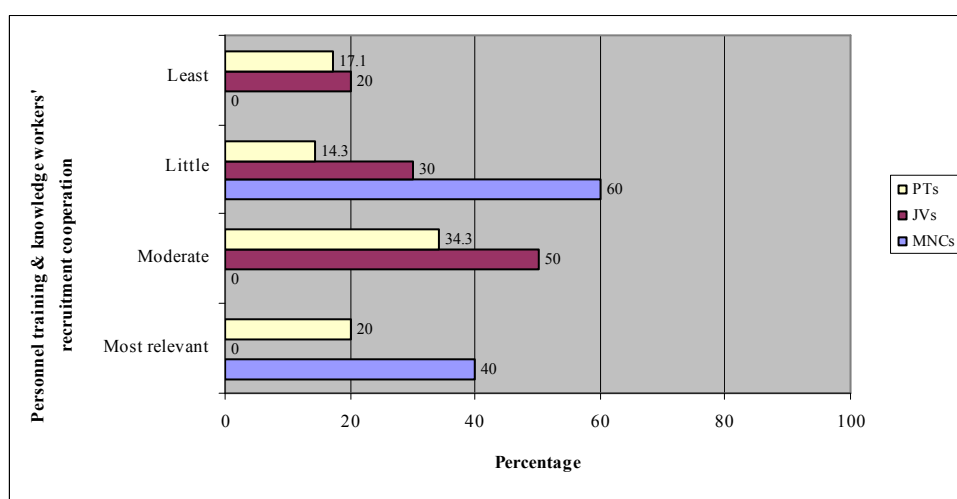


Figure 30: Level of cooperation between firms and universities/other organizations on personnel training and knowledge workers' recruitment (see Appendix G, Table 21)

4.2.4 Informal and formal cooperation with universities and other organizations

Informal and formal cooperation with universities and other organizations (such as research institutes and 'revolving' organizations) by auto part producers were as follows:

- 1) **Informal cooperation:** The sample of MNCs does not have any informal cooperation with universities and other organizations. Most of the JVs

cooperate with both universities and other organizations through personal contact with academic staff (62.5% with both universities and with other organizations), while most PTs also work together with both universities and other organizations through personal contact with academic staff, participation in seminars /conferences, engineering consultancy, and access to training courses (100%, 76.9%, 76.9%, and 76.9% respectively with both universities and other organizations). Most of the JVs and PTs in the sample therefore use personal contact with academic staff as the major way to enhance informal linkages (Figure 31 and Figure 32);

- 2) **Formal cooperation:** The MNCs, JVs, and PTs' in the sample have formal collaborations with both universities and other organizations. Most of the MNCs collaborate with universities through consultancy (100%) and with other organizations through consultancy and product/instrument testing contracts (100% and 100% respectively). Most of the JVs collaborate with universities through product/instrument testing contract and internship of science and technology undergraduates (100% and 100% respectively), and with other organizations through consultancy (100%). Most of the PTs collaborate with universities through consultancy (72.2%) and with other organizations through product/instrument testing contracts (100%). Consultancy is clearly the most popular means which both MNCs and PTs use to make links with universities, while product/instrument testing contracts and internship of science and technology undergraduates are the favourite choices among JVs. As for cooperation with other organizations, consultancy is an essential component for both MNCs and PTs, while product/instrument testing contract is the popular choice among MNCs and JVs (Figure 33 and Figure 34).

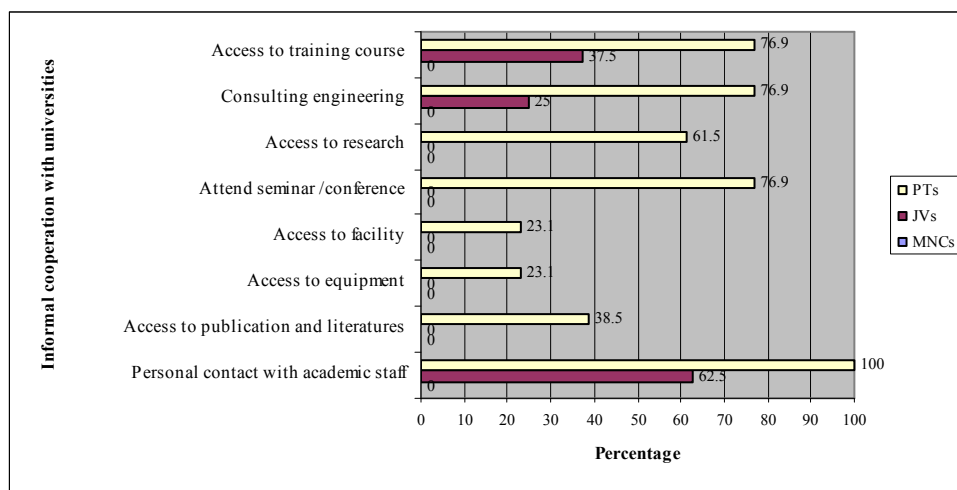


Figure 31: Informal cooperation with universities (see Appendix G, Table 22)

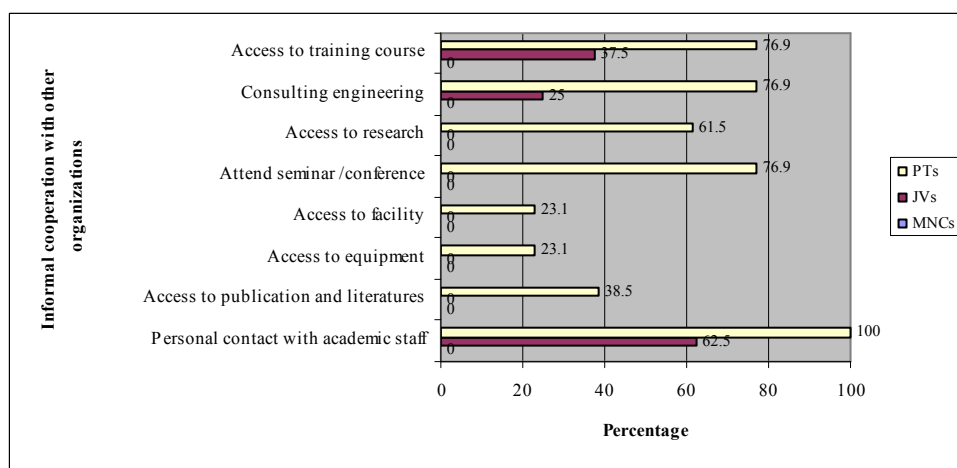


Figure 32: Informal cooperation with other organizations (see Appendix G, Table 22)

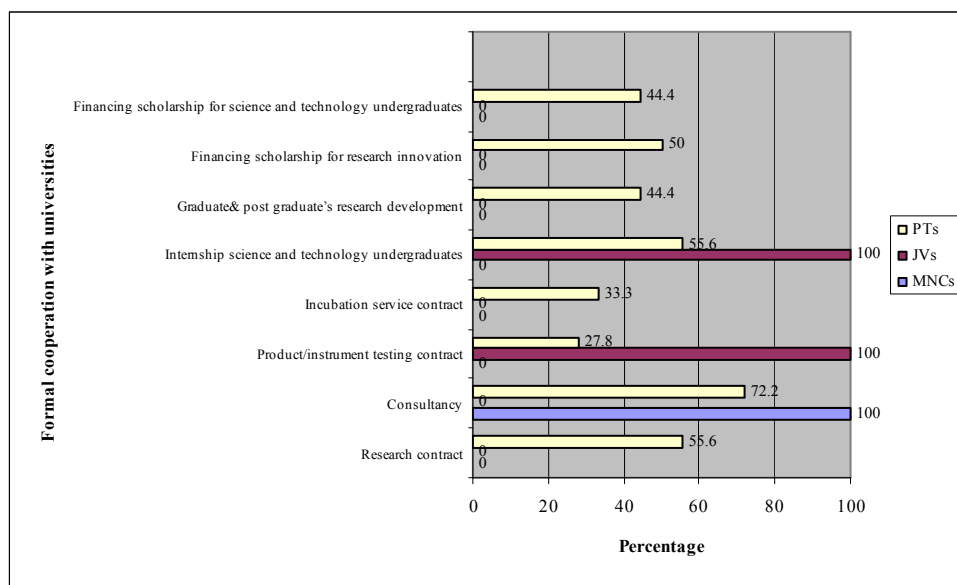


Figure 33: Formal cooperation with universities (see Appendix G, Table 22)

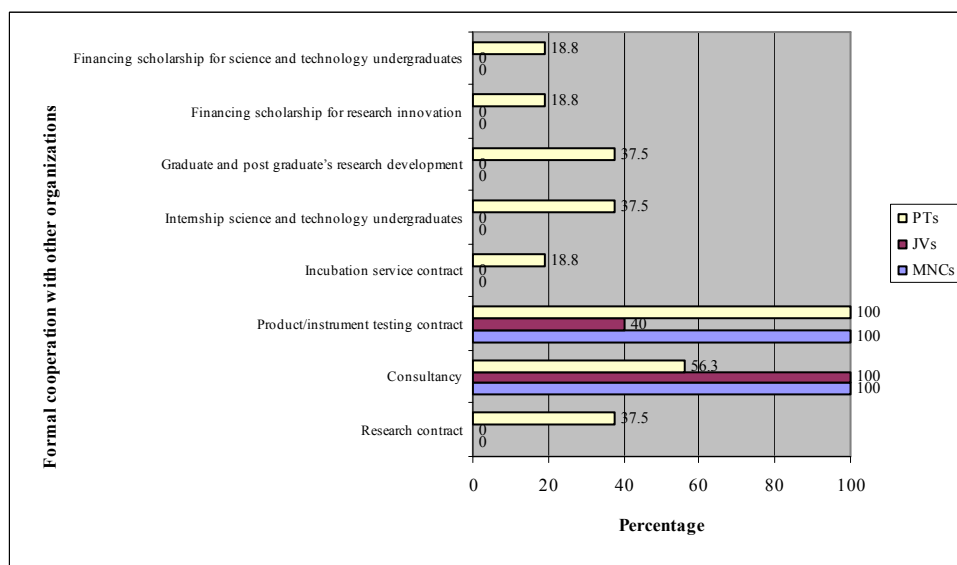


Figure 34: Formal cooperation with other organizations (see Appendix G, Table 22)

4.2.5 Improving firms' human resource development

Firms improve their human resource development through collaboration with universities and other organizations as follows:

- 1) Through universities, most MNCs recruit more experienced scientists and engineers (100%), most JVs recruit more experienced scientists and engineers and send employees to attend training courses at university (each field is 37.5%), and most PTs recruit more experienced scientists and engineers while sending employees to attend new technology training courses at universities (77.8% and 72.2% respectively). Recruiting more experienced scientists and engineers is clearly the most favoured means by which MNCs, JVs, and PTs use universities to improve their human resources (Figure 35);
- 2) MNCs also cooperate with other organizations for human resource development courses (100%). Most JVs use organizational consultancies, cooperate with organizations/institutes for human resource development courses, and send employees to attend training courses at organizations/institutes (100%, 71.4%, and 71.4% respectively), while most PTs select organizational consultancy (78.3%) from among these options. Cooperating with organizations/institutes for human resource development courses is therefore the preferred choice among MNCs and JVs, while using organizational consultancy is the practice that JVs and PTs most often choose to collaborate with organizations/institutes for human resource development (Figure 36).

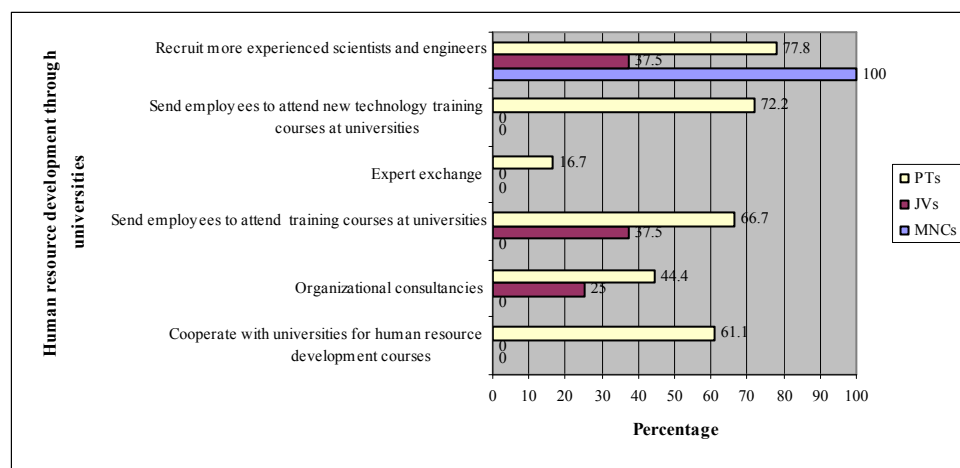


Figure 35: Human resource development through universities (see Appendix G, Table 23)

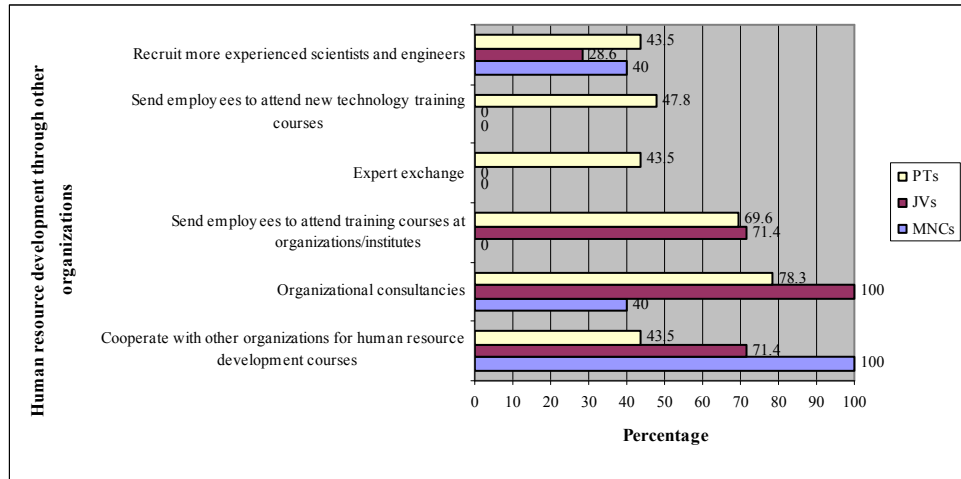


Figure 36: Human resource development through other organizations (see Appendix G, Table 23)

4.2.6 Supportive experts

It is only PTs that indicate they get supportive experts through engineering consultancy and science and technology expert consultancy (76.9% and 46.2% respectively). The survey shows that MNCs and JVs in the Thai automotive industry do not receive any supportive expert services from universities (Figure 37).

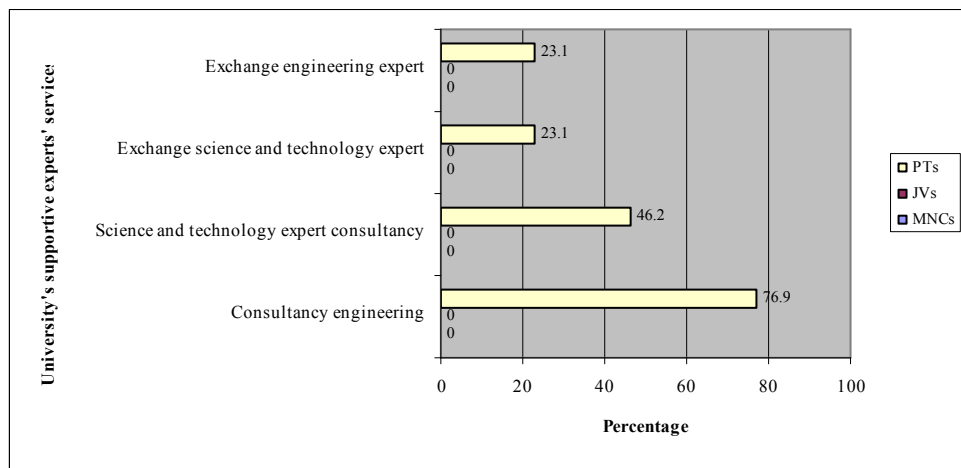


Figure 37: University's services of experts (see Appendix G, Table 24)

4.2.7 Firm's expectations from universities

MNCs expect universities to support human resource development and technology/process development (each with 100%) while most of the JVs and PTs expect human resource development support (100% and 84.6% respectively). Human resource development is the most expected service from universities for most MNCs, JVs, and PTs (Figure 38).

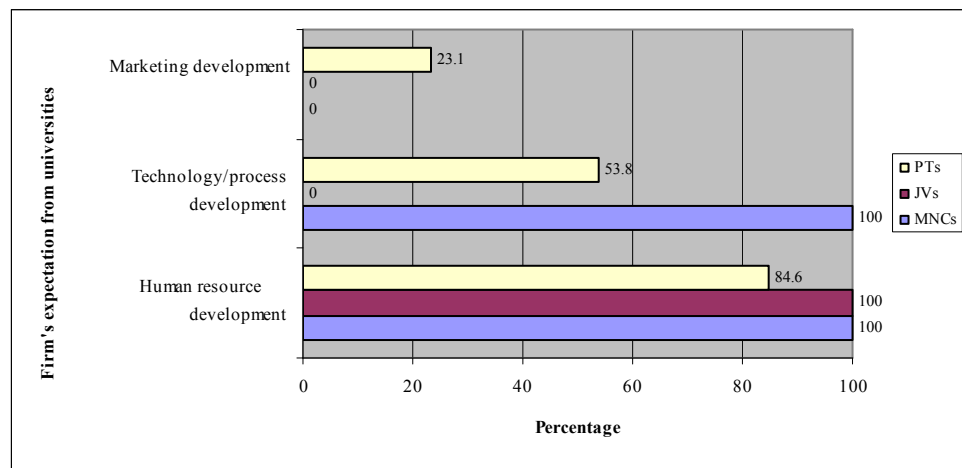


Figure 38: Firm's expectations to receive from universities (see Appendix G, Table 25)

4.2.8 Future cooperation with universities

Most MNCs' in the sample do not want to cooperate with universities (60%), giving as their major reason that they have had no contact with any university (60%). In contrast, most of the JVs' and PTs' would like to pursue collaboration with universities (100% and 71.4% respectively). Both JVs and PTs mention that they want firstly to cooperate with universities through training courses (100% and 66.7% respectively). In addition, most of JVs also want to collaborate through personal contact with academic staff (100%). Most JVs and PTs would therefore like to further collaborate with Thai universities in the future, even though present linkages are rather weak (Figure 39 to Figure 41).

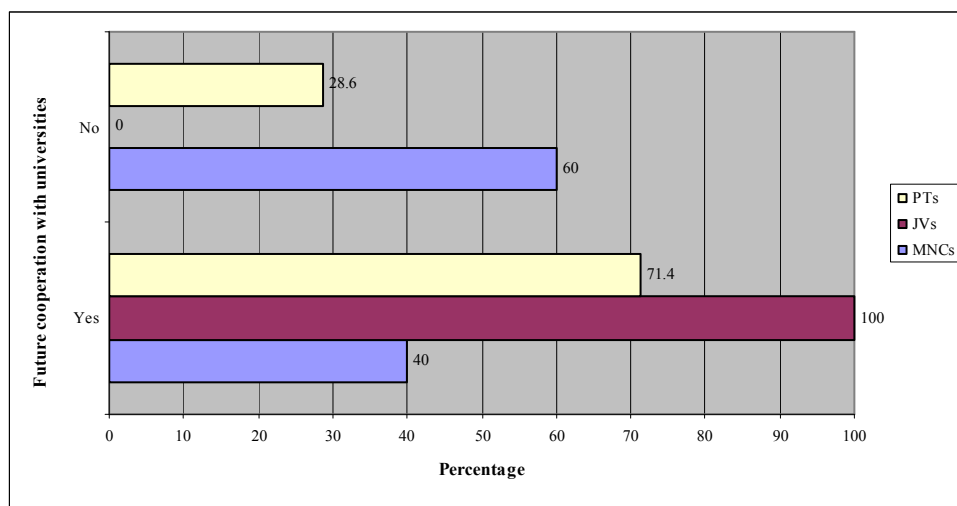


Figure 39: Interest in future cooperation with universities (see Appendix G, Table 26)

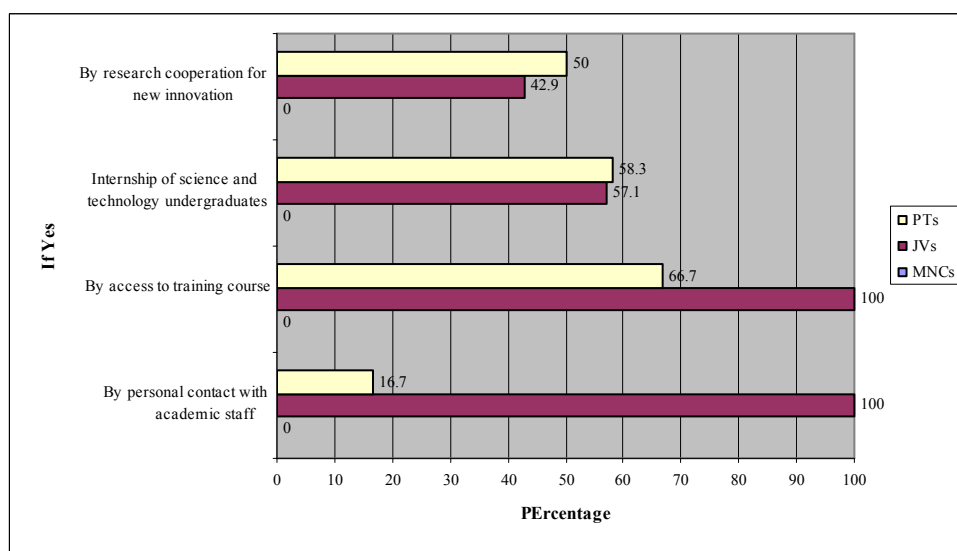


Figure 40: Field that firms want to cooperate with universities in the future (see Appendix G, Table 26)

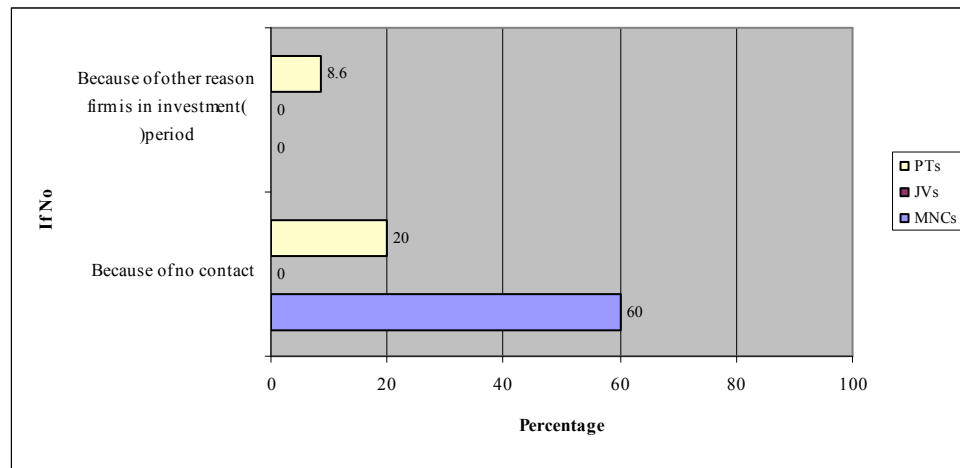


Figure 41: Reasons that firms do not want to cooperate with universities in the future (see Appendix G, Table 26)

4.2.9 Responses on the government's role

Government is the critical player that can effectively connect the universities with automotive industry. In the opinion of most of the MNCs, the government currently plays an inactive role in supporting the linkages (60%) and this makes national direction and policy to support the cooperation unclear, while there is no financial support from industry for university activities (each with 100%). However, most JVs and PTs view the present role of government as being an active one (80% and 47% respectively). In the opinion of most JVs, the government is setting a clear national direction and policy to support cooperation, generate university graduates increasingly relevant to automotive industry, enhance universities' role in transferring technology, and enhance universities' role in science and technology (each field with 62.5%). In the PTs' view, acting as an active player the government sets a clear national direction and policy to support cooperation, and produce university graduates increasingly relevant to the needs of the automotive industry (each with 78.6%). Overall, the data suggest that government should improve its role to gain more trust and more cooperation from the automotive industry, especially from the MNCs (Figure 42 to Figure 45).

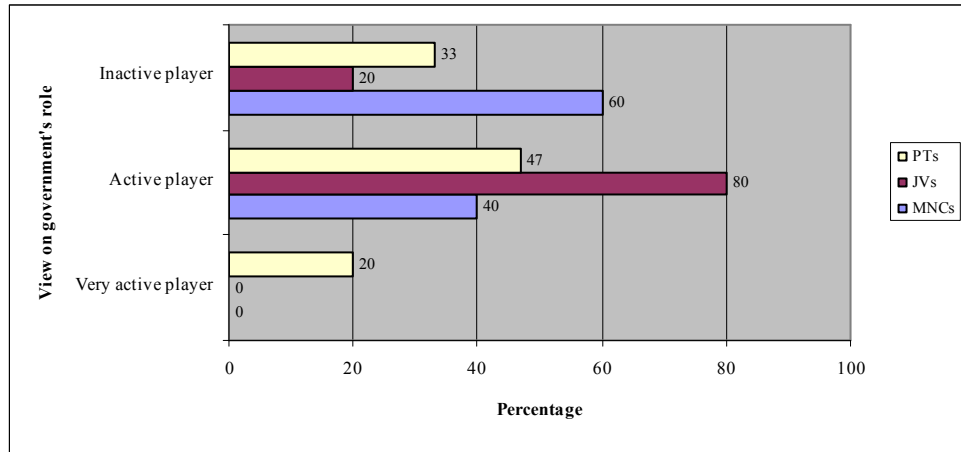


Figure 42: Views on government's role (see Appendix G, Table 27)

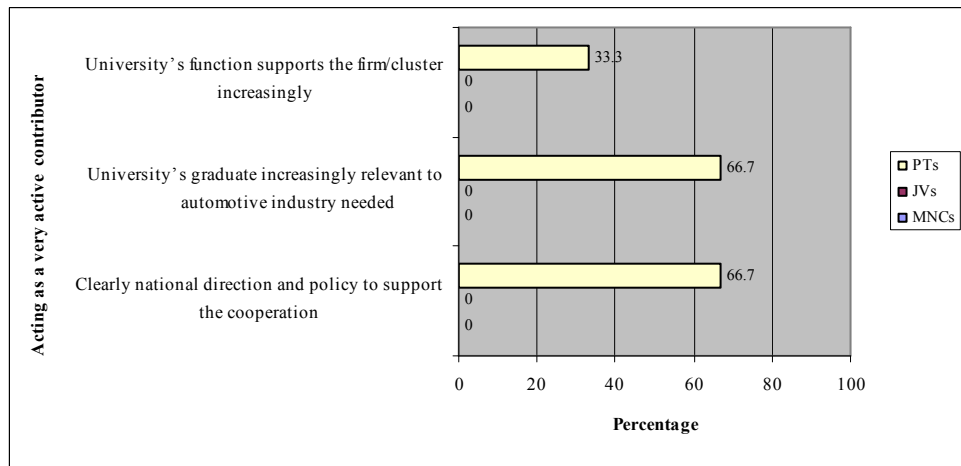


Figure 43: Impacts from government acting as a very active contributor (see Appendix F, Table 27)

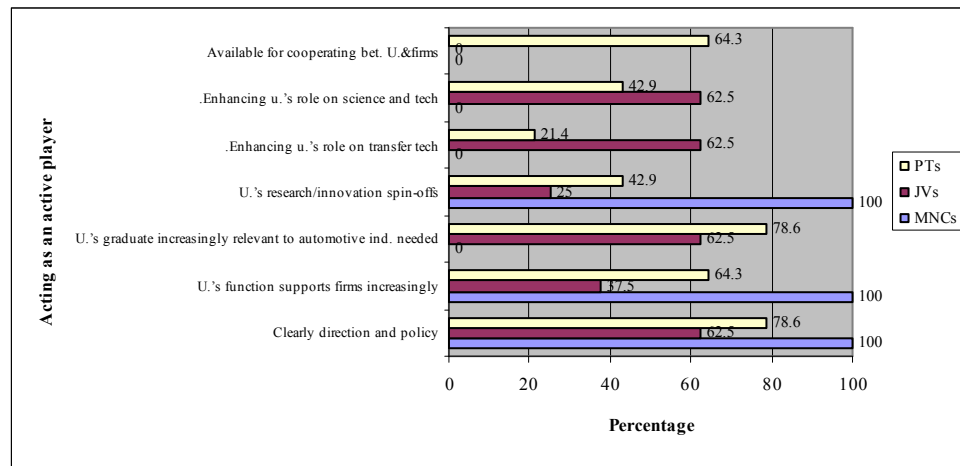


Figure 44: Impacts from government acting as an active player (see Appendix G, Table 27)

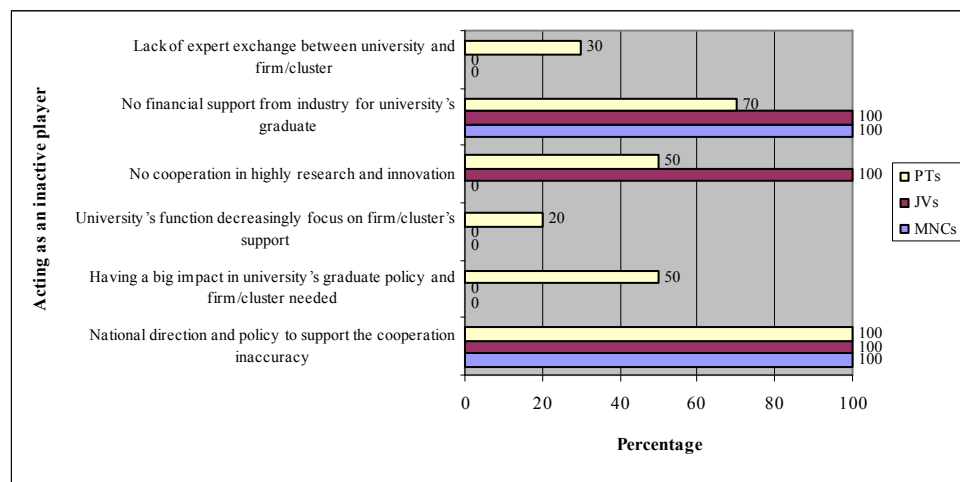


Figure 45: Impacts from government acting as an inactive player (see Appendix G, Table 27)

4.2.10 Cooperation model

To develop the appropriate cooperation model for more fruitful benefits, most MNCs and PTs have similar ideas that firms should make direct contact with universities for study or research for technological problem solving (100% and 70% respectively), while most JVs think that the Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association should play a cooperative role by collecting general

problems from firms and distribute them to universities for solutions and developing an expert exchange program between firms and universities (each with 70%). Thus the data reveals the widely-held view that automotive firms, universities, and related organizations (such as Thailand Automotive Institute and Thai Auto-Parts Manufacturers Association) should work together to develop an appropriate model of cooperation (Figure 46).

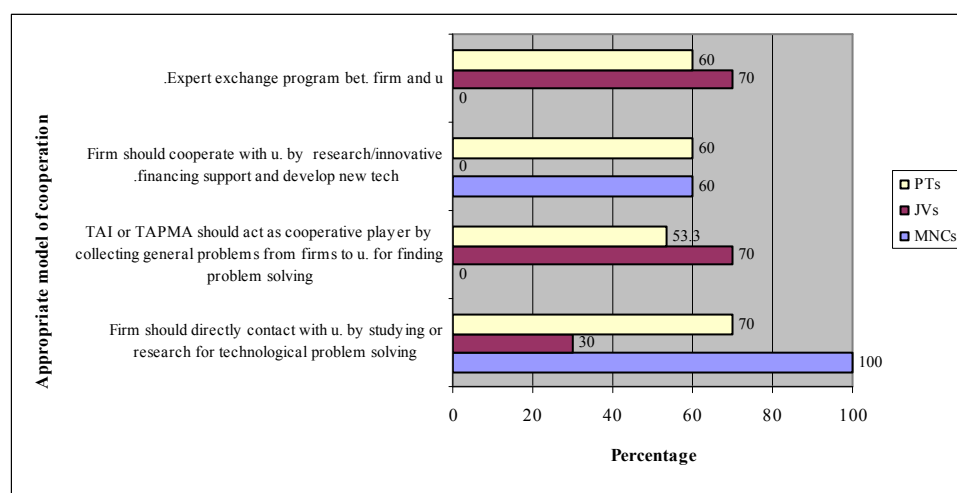


Figure 46: Appropriate cooperation between universities and firms
(universities' role & firms/cluster' role) (see Appendix G, Table 28)

4.2.11 Summary

From the MNCs, JVs, and PTs' findings above, it shows that most MNCs and JVs emphasize technology and marketing development. Most JVs would like to cooperate with prestigious universities, while most of MNCs focus more on opportunity and capacity for technology transfers. However, there is no cooperation between most MNCs and universities, while most of JVs have some cooperation through personal contact with academic staff under informal cooperation. Regarding formal cooperation, most MNCs have consultancy contracts with universities, and consultancy along with product/instrument testing contracts with other organizations. While cooperation between JVs and universities is mostly based on product/instrument testing contracts and internship of science and technology undergraduates, cooperation of JVs with other organizations is based around consultancy. Both MNCs and JVs expect universities to

enhance human resource development, while most MNCs also expect Thai universities to develop technology and engineering processes.

Turning to opinions toward the government's policy, most MNCs view the government as an inactive player, which makes the national direction and policy on supporting cooperation between the automotive industry and universities unclear and provides no financial support from industry for the universities' graduates. In contrast, most JVs believe that the government is an active player that sets a clear national direction and policy to support cooperation, universities' function to increasingly support firms/cluster, and universities' research/innovation spin-offs to serve the industry. As an appropriate cooperation model between universities and firms, most MNCs suggest that firms should directly make contact with universities to carry out studies or research for technological solutions, while most of JVs recommend that TAI or TAPMA should play a cooperative role by collecting general problems from firms and distributing them to universities for finding solution, and there should be an expert exchange program between firms and universities.

PTs' responses are as follows:

- 1) Firms need to develop technology, production, human resources and marketing to improve their competitiveness. In the PTs' view, these developments could be achieved by systematically managing a firm's expertise and knowledge, and cooperating with other organizations and firms with expertise in the cluster. They have little expectation of cooperation with universities for innovation and research. The reasons are that their production and technology are determined from their foreign 1st tier and parent companies/clients.
- 2) When the firms need to collaborate with universities, they are not concerned about proximity; they rather look at:
 - The reputation and prestige in high technology,
 - The quality in automotive engineering and management,
 - Quality of graduates' training and skills,
 - Opportunity and capacity for technology transfers.

- 3) Firms perceive that the level of collaboration with universities is moderate.
- 4) Firms have informal collaboration with universities and other organizations/ institutes through;
 - Personal contact with academic staff,
 - Access to training courses,
 - Engineering consultancy,
 - Participation in seminars /conferences,
 - Access to universities' research findings.
- 5) For formal cooperation with universities, firms employ consultancy, internship of science and technology undergraduates and research contracts. However, firms have little cooperation in product/instrument testing, graduate and post-graduate research development, financing scholarships for research innovation, financing scholarships for science and technology undergraduates and incubation services.
- 6) For formal cooperation with other organizations/institutes, firms seek testing product/instrument and consultancy.
- 7) To improve their human resource development through university links, firms need to;
 - Recruit more experienced scientists and engineers,
 - Send employees to attend training courses at universities,
 - Cooperate with universities for human resource development courses,
 - Employ consultancy for organizational development.
- 8) Firms expect benefit from collaboration with universities in human resource development and technology/engineering process development.
- 9) Some firms' opinions are that the government plays an active role in clarifying national direction and policy to support the cooperation, producing graduates who are relevant to firms' need and promoting universities to increasingly support the firms; while some other firms do not agree.

- 10) Firms need universities' support through engineering/science and technology consultancies, exchange of science and technology experts and engineering experts.
- 11) In term of supporting the automotive industry's competitiveness and sustainability, universities have to increasingly produce graduates who are relevant to the industry's need, support human resource development/training programmes, conduct engineering consultancy and enhance university-firm cooperation for technological problem solving.
- 12) Firms suggest the four types of collaborative relationship with universities. Three are collaborations of firms directly with universities: 1) study or research for technological solutions, 2) expert exchange programmes between firms and universities, and 3) research/innovative financial support to develop new technology. The fourth, indirect model is that the firms collaborate with universities through the Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association which act as collaborators between industry and university by collecting common problems from firms and encouraging universities to find solutions to these.
- 13) For some firms which do not collaborate with universities suggest a way to build collaboration in the future, namely access to training courses, internship of science and technology undergraduates, personal contact with academic staff and research cooperation for new innovations.

4.3 In-depth analysis of the Thai automotive industry

4.3.1 Thai automotive industry

The researcher interviewed informants from three firms (auto-part producer and auto assemblers); these are as follows:

1) Toyota Motor Thailand Co., Ltd.

The interviewee in this firm is the senior vice president for technical division. Toyota Motor Thailand Co., Ltd. was originally established in 1956 under the name, "Toyota

Motor Sales Co., Ltd." It was the first Toyota Company in Thailand, as well as the first Toyota Company established outside Japan. The main business was importing passenger cars and commercial vehicles, i.e. TOYO-ACE, MS 40, DA, and Land Cruiser. In 1965, Toyota was awarded BOI investment promotion privilege certification as an automobile assembler. Then, Toyota Motor Thailand Co., Ltd. came into being.

2) Thairung Union Car Public Co., Ltd.

The interviewee in this firm is the general manager. Thairung Union Car Public Co., Ltd. was originally established in 1967 by Mr. Vichien Paearnchok, an expert in modified pick-up cars, under the name, "Thairung Engineering Co., Ltd". It became Thairung Union Car Public Co., Ltd. in 1973. The main business is R&D, production of mouldings, handling equipment and parts, and assembling and modifying various types of car -especially modified station wagons and multipurpose cars.

3) Somboon Advance Technology Co., Ltd.

The interviewee of this firm is the executive advisor. Somboon Group was originally established in 1941 by Mr. Somboon Kitaphanich as Yong Kee Partnership Co., Ltd., a distributor of automobile parts. In 1962, the firm restructured into Somboon Spring Partnership Co., Ltd., manufacturer of springs for the domestic automobile industry. Since then Somboon Group has continually expanded their business through establishment of Somboon Malleable Iron Industrial Co., Ltd. in 1975, Bangkok Spring Industrial Co., Ltd. in 1977, Somboon Advance Technology Co., Ltd. in 1995, SAT Axle Technology in 2002, and became Somboon Advance Technology Public Co., Ltd. in 2004.

A summary of data from the interviews with these automotive industry representatives is shown in Table 12.

Table 12: Analysis of major auto-assemblers and auto-part producer in Thailand

	Toyota Motor (Thailand) Co, Ltd. <i>(Joint-venture auto assembler)</i>	Thairung Union Car Public Co., Ltd. <i>(Pure Thai auto assembler)</i>	Somboon Advance Technology Co., Ltd. <i>(Pure Thai auto-part producer)</i>
1. Existing level of university-automotive industry linkage ▪ With Thai universities	<p>High level of collaboration only with prestigious universities;</p> <ul style="list-style-type: none"> - Collaborating to establish automotive engineering curricula such as those of Chulalongkorn University, Kasetsart University, Siam University and Thai-Nichi Institute of Technology; - Accommodating plant visits; - Internship programme. 	<p>Low level of collaboration;</p> <ul style="list-style-type: none"> - Collaborating to establish an automotive engineering curriculum with King Mongkut's Institute of Technology North Bangkok; - Suggesting Chulalongkorn University should produce automotive graduates relevant to industrial need; - Little engineering consultancy with MTEC. 	<p>Middle level of collaboration;</p> <ul style="list-style-type: none"> - Cooperative education and internship programme with Suranaree University of Technology, King Mongkut's Institute of Technology North Bangkok, and Burapha University; - Joining with some universities to set an automotive curriculum; - Cooperating with Mahanakorn University of Technology to conduct some simulation tests on axle and automotive leaf spring in the production line;

	Toyota Motor (Thailand) Co, Ltd. <i>(Joint-venture auto assembler)</i>	Thairung Union Car Public Co., Ltd. <i>(Pure Thai auto assembler)</i>	Somboon Advance Technology Co., Ltd. <i>(Pure Thai auto-part producer)</i>
▪ With Thai auto-part producers	<p>High level of collaboration only with firms that are Toyota's members;</p> <ul style="list-style-type: none"> - Joining in the Automotive Human Resource Development Project, a governmental project to support Thai auto-part firms (SMEs); - Facilitating with members of Toyota such as Quality Assurance (QA) activities, Quality Control Cycle (QCC) activities, etc.; - Toyota Motor (Thailand) also cooperates with the Thai Automotive Institute in automotive workforce improvement, as Thai-Japanese cooperation. 	<p>High level of collaboration only with firms that are Thairung's members;</p> <ul style="list-style-type: none"> - Improving Thairung's suppliers by advising on process development such as Quality Control (QC) activities. 	<ul style="list-style-type: none"> - Collaborating with MTEC in generating researchers for entrepreneur program. <p>High level of collaboration only with firms that are Somboon Group's members;</p> <ul style="list-style-type: none"> - Improving Somboon Group's suppliers by advising on process development; for example, QC activity, Human Resource Development (HRD) activity, other technical solutions and funding.

	Toyota Motor (Thailand) Co, Ltd. <i>(Joint-venture auto assembler)</i>	Thairung Union Car Public Co., Ltd. <i>(Pure Thai auto assembler)</i>	Somboon Advance Technology Co., Ltd. <i>(Pure Thai auto-part producer)</i>
	<p>those of universities, while universities themselves do not develop new technology as they do not successfully aggregate knowledge of staffs</p> <ul style="list-style-type: none"> - Toyota often selects to cooperate with prominent universities; - Linkage between Toyota and non-members of Toyota is hard to emerge because Toyota mainly support its member; - Universities cannot produce graduates matching the industry's need; - Universities' supply of technicians to the automotive industry is inadequate; - Toyota recently has its own R&D centre and training centre in Thailand, which is an obstacle to cooperation with others and universities for R&D. 	<p>opinions or their needs with government sector;</p> <ul style="list-style-type: none"> - Most Thai auto-part firms' R&D is controlled by foreign clients; so there is no technology transfer or research cooperation for new innovation; - Thai universities usually cooperate with big companies rather than SMEs; - Thailand Automotive Institute is ineffective; - Not many universities are well-regarded in the automotive industry; - Universities' alumni in Thailand are not strong enough to effectively enhance industry-university linkage. 	<ul style="list-style-type: none"> - There is limited transfer of technology from Japanese companies to local firms; - Failure in generating relevant university graduates makes industry spend more on training costs and time; - Universities do not intend to develop industry-university linkage; for example, some research papers are not applicable/commercializable.

	Toyota Motor (Thailand) Co, Ltd. <i>(Joint-venture auto assembler)</i>	Thairung Union Car Public Co., Ltd. <i>(Pure Thai auto assembler)</i>	Somboon Advance Technology Co., Ltd. <i>(Pure Thai auto-part producer)</i>
	supply of technicians is insignificant to the industry.		cooperate with industry.
▪ Government	<ul style="list-style-type: none"> - Government should have a clear direction to support the automotive industry; - Governmental agencies should collaborate with others and identify a host to drive automotive industry support; - Government should develop automotive testing and testing centres to serve industry. 	<ul style="list-style-type: none"> - Government should have a clear direction support the automotive industry; - Government should increasingly establish research institutes or science and technology centres to improve national science and technology. 	<ul style="list-style-type: none"> - Government should have a clear direction to support the automotive industry.

4.3.2 Summary

Findings from these samples of the automotive industry's major firms show that most of them have closely cooperated with only their members or suppliers, while having different level of linkage with universities, depending on the level of trust. An important factor which enhances universities-industry linkage is the predominant impression/image of each other. The automotive industry is concerned about the little trust that industry generally gives to Thai universities. The reason is that most firms believe that the universities could not produce relevant graduates to serve industry's needs, most universities lack high-level technological knowledge to support industry, and faculty members specialize only on the academic side or can not adapt their knowledge to solve industrial problems. Automotive assemblers should enhance their collaboration with both Thai universities and auto-part producers, while universities should develop themselves to gain more trust; for example, universities should improve to generate graduates who increasingly meet the needs of industry. Furthermore, government should support the industry through dedicating itself to establishing a clear direction to foster the automotive industry.

4.4 In-depth analysis of Thai universities and industry linkage

Informants from eight universities provided information to the researcher through in-depth interviews. The universities could be categorized into two groups, namely – long-standing established universities and relatively less competitive universities, as described below:

4.4.1 Prominent/Long-standing established universities

1) Chulalongkorn University

The interviewee of this university is the head of the mechanical engineering department. Chulalongkorn University is a public university and a comprehensive university with high public recognition. It was Thailand's first institution of higher learning, founded by King Chulalongkorn in 1917. There are 18 faculties in total. Regarding automotive programmes, there are automotive design and manufacturing programmes (taught in

English) and an automotive engineering programme (taught in Thai). Undergraduate and graduate programs in automotive engineering are housed in the department of mechanical engineering. In addition, there are also some automotive-related fields, namely computing, electrical, environmental, industrial, mechanical, and metallurgical engineering departments.

2) King Mongkut's Institute of Technology North Bangkok

The three interviewees of this university are the head of the mechanical and aerospace engineering department, the director of the science and technology research centre, and the deputy director of automated manufacturing systems of the Thai-French Innovation Centre. King Mongkut's Institute of Technology North Bangkok is a prestigious public technical university. It was established through the co-operation between the Thai Government and the Federal Republic of Germany as the "Thai-German Technical School" in 1959 and became "King Mongkut's Institute of Technology North Bangkok" in 1971. There are seven faculties within the university, and automotive engineering programmes are housed within the department of mechanical and aerospace engineering. There are also some other auto-related curricula in electrical, manufacturing, industrial, production technology, material handling technology, and industrial electrical technology engineering departments.

3) King Mongkut's Institute of Technology Ladkrabang

The interviewee of this university is the head of the mechanical engineering department. King Mongkut's Institute of Technology Ladkrabang is a prestigious public technical. It was established in 1960 as the "Nonthaburi Telecommunication Institute" by the Ministry of Education and became the "King Mongkut's Institute of Technology Ladkrabang" in 1971. There are six faculties. Automotive-related courses take place in the department of mechanical engineering and some related fields are in control, electronics, instrumentation, computer, electrical, and industrial engineering department.

4) King Mongkut's University of Technology Thonburi

The interviewee of this university is the vice president. King Mongkut's University of Technology Thonburi is an autonomous university which is the first among public universities in Thailand to receive full autonomy and is a well-regarded technical university. It was established as the "Thonburi Technology Institute" in 1960 by the Department of Vocational Education, Ministry of Education, and became "King Mongkut's University of Technology Thonburi" in 1971. There are eight faculties in the university. Automotive-related courses are delivered in the department of mechanical engineering. In addition, automotive-related curricula are found in electrical, production, computer, environmental, control system and instrumentation, electronics and telecommunication, and tool and material engineering departments.

A summary of the interview data from long-standing established universities is shown in Table 13.

Table 13: Analysis of prominent/long-standing established universities

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
1. Existing level of university-automotive industry linkage ▪ With auto-assemblers ▪ With auto-part producers	<p>High level collaboration only with the country's largest player, Toyota Motor (Thailand) Co., Ltd.;</p> <ul style="list-style-type: none"> - Collaborating to establish the automotive engineering curriculum; - Funding and instrumental support; - Internship. <p>Low level of collaboration;</p> <ul style="list-style-type: none"> - Research cooperation for auto-parts or production line improvement; - Internship programme; 	<p>Low level of collaboration;</p> <ul style="list-style-type: none"> - Cooperative education and internship programme. <p>Middle level of collaboration;</p> <ul style="list-style-type: none"> - Engineering consultancy; - University-firm cooperation, for example: <ul style="list-style-type: none"> - Technological problem solving such as simulation, analysis in production line/cost control, etc.; - In the case of King Mongkut's Institute of Technology North Bangkok, there is some cooperation between KMITNB

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
		<p>(Thai-French Innovation Centre), government (Department of Industrial Promotion), and some automotive firms (Thairung Union Car Public Co., Ltd., Thai Summit Auto Body Industry Co., Ltd., Thai Summit Auto Parts Industry Co., Ltd.) for auto-part design, e.g., cushions, bumpers, oil tanks, cache, etc. in 2006.</p> <ul style="list-style-type: none"> - Support for human resource development course; - Incubation services and facilities such as testing services, laboratory services, business training, etc.; - Cooperative education and internship programme.
2. Strengths and weaknesses of linkages ▪ Strengths	- Reputation of university (the most important	- Personal contact (the most important

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
	factor); - Personal contact; - Some alumni become executive officers of large firms such as Toyota Motor (Thailand) Co., Ltd.	factor); - Reputation of universities as notable technical universities can gain more trust from small and medium enterprises to help them solve their technical problems, especially Quality Assurance (QA) problems (the most important factor); - Reputation of faculty members (the most important factor); - Alumni network.
▪ Weaknesses	- Most Thai auto-part firms' R&D is controlled by clients that are foreign companies; - Mismatch between short run industrial needs and long-term investment in research and capacity building; - Problems are often simple and not attractive to university's interest; - Automotive issues are more interdependent and	- Assemblers have their own R&D, so it is not necessary to join with a university; - Most Thai auto-part firms' R&D is controlled by clients that are foreign companies; technology transfer and research cooperation for new innovation are thus on a small scale; - Mismatch between short-term industrial needs and long-term investment in research and

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
	complex than what university alone can handle.	capacity building.
3. Paths to improve automotive industry-university linkage ▪ Universities	- University should generate graduates increasingly relevant to automotive industrial need.	- University should generate increasingly relevant graduates to serve automotive industry's need (more responsible, more adaptive and more honest); - University should transfer technology to help Pure Thai auto-part firms, especially SMEs, to produce high quality products; - University should cooperate with Pure Thai auto-part firms through research to develop more valued-added products; - Faculty members and researchers should open their minds for working with the private sector

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
		<p>in the real world;</p> <ul style="list-style-type: none"> - University should present their capacity to be known in industry for furthering cooperation; - In King Mongkut's Institute of Technology North Bangkok's view, Thai universities should set model - clearly divide professors' roles into 3 parts, i.e. teaching, research, and industrial service with effective financial management , like Aachen University in Germany
▪ Automotive industry	- Firms should maintain long-term relationships for business development opportunities.	- Firms should frequently cooperate with university through research/innovative financial support and develop new technology;

	Chulalongkorn University	King Mongkut's Institute of Technology North Bangkok King Mongkut's Institute of Technology Ladkrabang King Mongkut's University of Technology Thonburi
▪ Government	<ul style="list-style-type: none"> - Government should clearly identify which segments are to be promoted; - Government should control conditions/ environment that can affect the automotive investment atmosphere, such as free-trade conditions, suitable wages and connections between government and automotive industry, etc. 	<ul style="list-style-type: none"> - Local firms should create partnership with big foreign companies for more opportunities in this industry. - Government should clearly identify which segments (i.e. production, marketing, human resource development) are to be promoted for more effective linkage among government, university and automotive industry; - Government should establish centre of excellence, which gathers all universities' information and instrumental support to be a one stop service centre, to serve industry.

4.4.2 Universities that are either new or recently upgraded from technical college

1) Rajamangala University of Technology Thanyaburi

The interviewee is the head of the mechanical engineering department. Rajamangala University of Technology Thanyaburi is a public university which is a technical university upgraded from a polytechnic. It was established in 1975 as the “Institute of Technology and Vocational Education” and became “Rajamangala University of Technology Thanyaburi” in 1988. There are ten faculties within the university, and automotive programme is housed in the department of mechanical engineering. Other departments related to automotive engineering are electrical, industrial, electronics and telecommunication, computer, and materials and metallurgical engineering.

2) Rajamangala University of Technology Phra Nakhon North Bangkok Campus

The interviewee is the head of the mechanical engineering department. Rajamangala University of Technology Phra Nakhon North Bangkok is a public university which is a technical university upgraded from a polytechnic. It was known before as “Rajamangala Institute of Technology” and became one of five campuses of “Rajamangala University of Technology Phra Nakhon” in 2005. There are nine faculties, and automotive programme is housed in the department of mechanical engineering and auto-related departments are electrical, computer, and industrial engineering.

3) Mahanakorn University of Technology

The interviewee is the head of the mechanical engineering department. Established in 1990, Mahanakorn University of Technology is a private science and technology university. The university is distinct through having its own micro-satellite “Thai Paht” and its on-campus ground station. There are five faculties within the university and automotive programme is housed in the department of mechanical engineering. Other departments related to automotive engineering are in electronic, computer, control and instrumentation, electrical power, industrial, and mechatronic engineering department.

4) Siam University

The interviewee is the head of the automotive engineering department. Siam University is a private university which was established in 1965 as a “Private Higher Education Institution” with authorization to grant degrees given in 1973. It has eight faculties. There is an automotive engineering department, directly relevant to the automotive sector. However, some other departments are also related to automotive engineering; these are mechanical, electrical, and computer engineering.

A summary of the interview data from relatively less competitive universities is shown in Table 14.

Table 14: Analysis of relatively less competitive universities

	Rajamangala University of Technology Thanyaburi Rajamangala University of Technology Phra Nakhon North Bangkok Campus	Mahanakorn University of Technology Siam University
1. Existing level of university-automotive industry linkage <ul style="list-style-type: none"> ▪ With auto-assemblers ▪ With auto-part producers 	<p>Very low level of collaboration;</p> <ul style="list-style-type: none"> - Internship programme; - No collaboration in research projects. <p>Low level of collaboration;</p> <ul style="list-style-type: none"> - Support for human resource development course; - Attend some contests such as Auto-challenge contest, Smart car contest; - Cooperative education and internship programme. 	<p>Rarely have any collaboration.</p> <p>Very low level of collaboration;</p> <ul style="list-style-type: none"> - University-firm cooperation for technological problem solving such as simulation for product improvement; - Internship programme.
2. Strengths and weaknesses of linkage <ul style="list-style-type: none"> ▪ Strengths 	<ul style="list-style-type: none"> - Reputation on technical education as the university was a polytechnic is the most 	<ul style="list-style-type: none"> - Personal contact.

	Rajamangala University of Technology Thanyaburi Rajamangala University of Technology Phra Nakhon North Bangkok Campus	Mahanakorn University of Technology Siam University
▪ Weaknesses	<p>important factor for firms to consider cooperation;</p> <ul style="list-style-type: none"> - Personal contact. - Assemblers have their own R&D, so it is not necessary to join with university; - Most Thai auto-part firms' R&D is controlled by foreign clients, so technology transfer or research cooperation for new innovation are prohibited; - Assemblers believe that the university's capacity is less than industry's. 	<ul style="list-style-type: none"> - Private university's image is not attractive for industry to cooperate; - Private universities do not get any direct funding from government for enhancing linkage with industry; - Most Thai auto-part firms' R&D is controlled by foreign clients.
3. Ways to improve automotive industry-university linkage ▪ Universities	<ul style="list-style-type: none"> - University should provide needed training course for industry; - University should generate graduates increasingly relevant to automotive industry. 	<ul style="list-style-type: none"> - University should generate graduates increasingly relevant to the automotive industry; - University should cooperate for technological

	Rajamangala University of Technology Thanyaburi Rajamangala University of Technology Phra Nakhon North Bangkok Campus	Mahanakorn University of Technology Siam University
<ul style="list-style-type: none"> ▪ Automotive Industry ▪ Government 	<ul style="list-style-type: none"> - Firms should provide some opportunities for university to collaborate; - Firms should cooperate with university through research/innovative financial support and development of new technology; - Firms should introduce themselves to be known to graduates/universities. - Government should have clear direction to support the automotive industry. 	<p>problem solving with industry.</p> <ul style="list-style-type: none"> - Firms should cooperate with university through research/innovative financial support and development of new technology; - Firms should introduce themselves to be known to graduates/universities. - Government should have clear direction to support the automotive industry.

4.4.3 Summary

Overall findings from samples of universities show that Thai universities still have low levels of cooperation with the automotive industry, both auto-assemblers and auto-part producers. Major reasons behind this are that most of Thai auto-part firms' R&D is controlled by clients that are foreign companies; technology transfer and research cooperation for new innovations are thus on a small scale. In general, universities themselves comment that they should produce graduates increasingly relevant to automotive industrial needs, while industry should support funding through research and innovation, and also collaborate to develop new technology. Moreover, government should have a clear direction for support of the automotive industry.

4.5 In-depth analysis of Thai research institutes and related organizations

4.5.1 Research institute

Thailand's Metal and Material Technology Centre (MTEC) is an example of Thailand's research institutes. The interviewee is the director of MTEC. MTEC operates as one of the technology centres under the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology. It was founded as a special governmental agency which supports material science and technology research and development, including manufacturing and design for both public and private companies/institutions. Located within Thailand's Science Park, it helps facilitate a cooperative atmosphere which propels and sustains the industrial development, economic growth and environmental well being of the nation.

4.5.2 Related organizations

The researcher examined four major organizations related to the automotive industry; these are as the following:

1) Thailand Automotive Institute (TAI)

The interviewee is the director of TAI. TAI is an independent organization established in 1998 by the Ministry of Industry through cooperation between the public and private sectors. It serves as the centre for development of Thailand's automotive industry and enhances its competitiveness in the international market.

2) Thai Auto-Parts Manufacturers Association (TAPMA)

The interviewee is the director of the SMEs development project. Established in 1978, TAPMA is a gathering of auto parts manufacturing companies from the private sector to serve as the collective voice of auto parts industrialists in the country to protect, support and develop the industry. TAPMA was also created to detect and address problems that hinder the automobile industry's development in terms of production technology's efficiencies, difficulties concerning raw material import and workforce challenges in attracting and developing skilled labourers and engineers.

3) Society of Automotive Engineer of Thailand (TSAE)

The interviewee is the president of TSAE. Established in 1997 by a group of engineers, academicians, scientists, and people involved in the automobile industry from state enterprises, public and private sectors, TSAE is a non-profit organization with roles in providing various assistance on technology and research issues in the automotive fields and also in the development of automobile industries in Thailand.

4) Thai Automotive Industry Association (TAIA)

The interviewee is president of TAIA. Established in 1981, TAIA is a private organization serving as the centre for Thailand's automotive industries. TAIA's objectives are to coordinate and act as an intermediary among its members for the prosperity of the automotive industry and to implement government industrial development policy to improve the national economy.

A summary of the interview data from research institutes and revolving organizations is shown in Table 15 and Table 16.

Table 15: Analysis of Thailand's Metal and Materials Technology Centre (MTEC)

	Thailand's Metal and Materials Technology Centre (MTEC)
1. Existing level of universities-automotive industry-organization linkage ▪ Organization-universities linkage ▪ Organization-automotive industry linkage	<p>Low level of collaboration between universities- automotive industry- organization linkage.</p> <p>Low level of collaboration;</p> <ul style="list-style-type: none"> - Providing funding support on research, MTEC funds only faculty members who conduct research with firms and the research proposals must be clear in necessity, solution, differentiation, and benefit. From this condition, there are not many professors who intend to conduct such research - Providing funding support for establishment of Industry/University Corporative Research Centre (I/UCRC) for helping automotive industry. <p>Moderate level of collaboration;</p> <ul style="list-style-type: none"> - Direct relationship: MTEC supports materials science and technology research and development, including manufacturing and design, for example, using computerized analysis to solve handling equipment and brake design problems, and to shape the effective body-parts for helping some auto-part firms etc.; - Indirect relationship: MTEC supports universities to establish an Industry/University Corporative Research Centre (I/UCRC) for helping

	Thailand's Metal and Materials Technology Centre (MTEC)
	the automotive industry because one mission of MTEC is to establish a national science and technology infrastructure.
2. Strengths and weaknesses of linkage ▪ Strengths	<p>For MTEC-universities linkage;</p> <ul style="list-style-type: none"> - MTEC has funding and resources that can attract universities to cooperate. <p>For MTEC-automotive industry linkage;</p> <ul style="list-style-type: none"> - MTEC 's mission is to support national industry in materials science and technology research and development.
▪ Weaknesses	<p>For MTEC-universities linkage;</p> <ul style="list-style-type: none"> - MTEC does not seriously and actively proceed on collaboration with universities. <p>For MTEC-automotive industry linkage;</p> <ul style="list-style-type: none"> - MTEC does not seriously and actively proceed on collaboration with automotive industry; - Persuading some Thai automotive firms to set up offices in MTEC' s area for R&D cooperation is somewhat difficult because most firms view R&D investment as a useless expenditure.
3. Ways to improve automotive industry-university linkage	

	Thailand's Metal and Materials Technology Centre (MTEC)
<ul style="list-style-type: none"> ▪ Universities, automotive industry, and government 	<ul style="list-style-type: none"> - Faculty members from universities, researchers from MTEC, and users from industrial sector should work together; - Professors should open their minds to work with the private sector in the real world; - Thailand Automotive Institute should urgently establish car testing centre and car testing ground for determining the quality of developed parts and accelerating Thailand to become the 'Detroit of Asia' soon. At the present, Thai-developed parts have to be tested in foreign countries (such as China, Japan, and United State of America) with high fees. If this situation remains in the future, Thai auto-technology will tend to be imitated and foreign auto-parts will tend to flood into Thailand because of lower tariff and trade barriers through the AFTA agreement (in the next 3 years) and Thailand-Japan FTA (in the next 4 years).

Table 16: Analysis of four major related organizations

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
1. Existing level of universities-automotive industry-organization linkage	Low level of collaboration among universities-automotive industry-organization.	Low level of collaboration among universities-automotive industry-organization.	Low level of collaboration among universities- automotive industry-organization.	Low level of collaboration among universities-automotive industry-organization.
▪ Organization-Universities linkage	Low level of collaboration.	Low level of collaboration.	Moderate level of collaboration; - Training courses.	Low level of collaboration.
▪ Organization-automotive industry linkage	Middle level of collaboration; - Training and consultancy by Thai and Japanese experts; - Testing service; - Information technology centre;	High level of collaboration; - Supports members through tackling problems and negotiating on behalf of members to establish mutual benefits to their enterprises and the industry	Middle level of collaboration; - Training industry such as QA programme, QCC programme, productivity improvement programme etc.	Middle level of collaboration; - TAIA serves as a clearing house for exchanging news and information among members.

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	<ul style="list-style-type: none"> - TAI also cooperate with Japanese companies: Toyota Motor (Thailand) Co., Ltd., Denso Co., Ltd., Honda Automobile Co., Ltd., and Siam Nissan, as Thai-Japanese Cooperation, to improve automotive workforce; 	as a whole.		
2. Strengths and weaknesses of linkage <ul style="list-style-type: none"> ▪ Strength 	For TAI-universities linkage; -	For TAPMA-universities linkage; -	For TSAE-universities linkage; - Trust in a long-standing president of TSAE who is a professor at Chulalongkorn	For TAIA-universities linkage; -

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
▪ Weakness	<p>For TAI-automotive industry linkage;</p> <ul style="list-style-type: none"> - As TAI's main objective is to develop the Thai automotive industry, many firms are members. <p>For TAI-universities linkage;</p> <ul style="list-style-type: none"> - TAI does not play the Role of a coordinator between educational and industrial sector; TAI only introduces the match of university- firm partner; 	<p>For TAPMA-automotive industry linkage;</p> <ul style="list-style-type: none"> - Many firms are members of TAPMA. <p>For TAPMA-universities linkage;</p> <ul style="list-style-type: none"> - There is no impression of trust from most of TAPMA's members toward universities since universities can not 	<p>University.</p> <ul style="list-style-type: none"> - Many universities are member of TSAE <p>For TSAE-automotive linkage;</p> <ul style="list-style-type: none"> - Industry's trust in a long-standing president of TSAE. - Many firms are members of TSAE <p>For TSAE-universities linkage;</p> <ul style="list-style-type: none"> - TSAE lacks funding to support the society and does not get any support from governmental agencies; 	<p>For TAIA-automotive industry linkage;</p> <ul style="list-style-type: none"> - Many firms are members of TAIA. <p>For TAIA-universities linkage TAIA-automotive industry linkage;</p> <ul style="list-style-type: none"> - This association aims to mainly provide information for members, so TAIA does not

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	<ul style="list-style-type: none"> - There are only a few universities interested in automotive research; - There are only a few universities operating an automotive engineering programme, such as Chulalongkorn University. <p>For TAI-automotive industry linkage;</p> <ul style="list-style-type: none"> - TAI emphasizes research in term of policy, not technical engineering research. This reduces collaboration between TAI and small/medium enterprise because TAI 	<p>produce relevant graduates;</p> <ul style="list-style-type: none"> - Some of TAPMA's members (SMEs) have no vision to conduct research for competitiveness because they mainly deal with purchasing and selling. <p>For TAPMA-automotive industry linkage;</p> <ul style="list-style-type: none"> - There is some competition among TAPMA's members because they produce similar products; thus cooperation might be difficult. 	<p>For TSAE-automotive industry linkage;</p> <ul style="list-style-type: none"> - TSAE lacks funding to support the society and does not get any support from governmental agencies; 	<p>concentrate on enhancing university-industry-organization linkages.</p>

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	<p>can not help them solve any process problems;</p> <ul style="list-style-type: none"> - TAI does not play the Role of a coordinator between educational and industrial sectors, TAI only introduces the match of university-firm partner. 			
3. Ways to improve automotive industry-university linkage <ul style="list-style-type: none"> ▪ Universities 	<ul style="list-style-type: none"> - Universities should use their expertise for conducting applied research to solve industrial problems, create innovation for the automotive industry with effective teamwork; 	<ul style="list-style-type: none"> - Universities have to produce graduates to meet the needs of firms; - Universities should collect the experts to seriously solve industrial problems (an expert specialises in one technology/problem), 	<ul style="list-style-type: none"> - Universities should generate graduates increasingly relevant to automotive industry's needs; - Universities should maintain and develop technical diploma programmes because the supply of technicians 	<ul style="list-style-type: none"> - Universities should be improved to generate graduates increasingly relevant to automotive industrial needs; - Lesser-known universities should present their capacity to be perceived

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	<ul style="list-style-type: none"> - Faculty members should enhance effectiveness and application in research papers and knowledge; - Universities should adjust their policies, management, and executives' vision to make it easier for cooperation with industry, such as King Mongkut's University of Technology Thonburi which became an autonomous university; - Universities should use regional cooperation strategy to enhance linkage with pure Thai firms; for example, Siam University 	<p>different from German and Japanese experts who have expertise in all technology;</p> <ul style="list-style-type: none"> - Faculty members should understand real demands of industrial sector because universities currently lack necessary automotive experience and are often concerned about quantity more than quality of research. 	<p>is significant for the industry;</p> <ul style="list-style-type: none"> - Universities should improve their staff's capacity in teaching and research. 	<p>by automotive industry for more cooperation with the industry;</p> <ul style="list-style-type: none"> - Universities should maintain and develop technical diploma programmes because the supply of technicians is significant for the industry.

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	<p>should develop a relationship with firms in western Thonburi area, Burapha University should work together with firms in the east of Thailand, etc.;</p> <ul style="list-style-type: none"> - Universities should create core competencies and invest to upgrade faculty members to attract cooperation; - Both universities and firms should increasingly create mutual understanding for effective cooperation, rather than having different visions: universities are only 			

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	concerned with academic values, while firms concentrate on maximizing profit.			
▪ Automotive industry	<ul style="list-style-type: none"> - Automotive firms should focus more on R&D for increasing the value of their products; - Firms should contribute their experiences to universities for enhancing the potentials of faculty members; - Both universities and firms should not only be concerned about quality of new graduates, but also improving quality of 200,000 workers in the 	<ul style="list-style-type: none"> - Both universities and industry should cooperate in improving the automotive curriculum to be relevant to industrial need. 	<ul style="list-style-type: none"> - Firms, both assemblers and auto-part producers, should improve and increase the level of their collaboration with universities and government. 	<ul style="list-style-type: none"> - Assemblers should enhance support to auto-part firms, especially 2nd and 3rd tier; - Firms, both assemblers and auto-part producers, should increase their collaboration with universities.

	Thailand Automotive Institute (TAI)	Thai Auto-Parts Manufacturers Association (TAPMA)	Society of Automotive Engineer of Thailand (TSAE)	Thai Automotive Industry Association (TAIA)
	automotive workforce, especially in small and medium enterprises.			
▪ Government	<ul style="list-style-type: none"> - Government should act as a central coordinator to enhance linkage between universities and industry through funding to support university research and promote effective policy. 	<ul style="list-style-type: none"> - In terms of AFTA and JTEPA, Japan has incentives to locate more 1st tier or 2nd tier firms in Thailand. If government has not dealt with existing industrial challenges, it will destroy the SMEs that are not sufficiently competitive to compete with Japanese firms. 	<ul style="list-style-type: none"> - Government should have clear direction to support automotive industry; - All related sectors should seriously and actively collaborate together. 	<ul style="list-style-type: none"> - Government should have clear direction to support automotive industry; - Government agencies should join together and identify a host agency to drive automotive industry support; - Government should establish automotive testing and testing centres to serve industry.

4.5.3 Summary

Findings from the samples of research institutes and related organizations reveal that organization and industry linkage is at a moderate level, while organization and university linkage is at a low level. This is because many firms are members of those organizations, while most university's faculty members are not associated with relevant organizations. A key factor that makes relevant organizations unable to successfully push the industry-universities linkage is that most of them lack sufficient funding to support such activities and some do not have the mission to promote such linkages. Most automotive organizations suggest that universities, industry, and government should work together to promote effective linkages for industrial competitiveness.

4.6 Conclusion of results and findings

The Thai automotive industry had historically been based and dependent on import-substitution policies of the country. At the present, the interest has shifted toward more liberalized policies to correspond with the current global paradigm. A major problem for Thai automotive competitiveness is the shortage of skilled workers as engineers, technicians, and supervisors. There are three major reasons why the current shortage of skills exists. First, there is **a lack of linkages between universities and automotive companies**, such that there is a mismatch between graduates' skills and companies' requirements. Second, there is **a weak technical base of workers** as products of the education system. This affects most companies to have high training costs to alleviate workers' skills to perform. Third, although foreign workers can be hired to fill some of the skills gaps, **the hiring process for foreigners is overly bureaucratic in complying with legal requirements**.

The result of the auto-part producers' survey shows that MNCs, JVs, and PTs have some cooperation with Thai universities in various activities. Most MNCs cooperate with universities in the areas of marketing and human resource development, rather than product/technology development and recruitment of knowledge workers. JVs-universities cooperation is at a moderate level in personnel training and knowledge workers' recruitment and at the least level in technology, product, marketing, and human

resource development. Meanwhile PTs-universities cooperation is at a moderate level in personnel training, knowledge workers' recruitment, technology, product, and human resource development; marketing development is at low level.

Most MNCs do not cooperate with Thai universities, while most JVs and PTs have some cooperation. The level of collaboration with universities and related organizations is rather moderate.

A high level of informal collaboration between firms and both universities and other organizations exists through personal contact with academic staff, access to training course, engineering consultancy, participation in seminar/conference, and access to research. For high levels of formal cooperation with universities, firms employ university consultancy, internship of science and technology undergraduates and research contracts. Firms have rather less cooperation in research for development, financing scholarships for research innovation, financing scholarships for science and technology undergraduates and incubation services.

Most firms expect benefits from collaboration with universities in human resource development and technology/process development. In terms of supporting the automotive industry to be more competitive and sustainable, universities have to increasingly produce graduates who are relevant to industry' s needs, support human resource development/training programmes, conduct engineering consultancy, and enhance universities-firms cooperation for technological problem solving.

Regarding interviewees' advice on collaborative relations between firms and universities, firms and universities should directly collaborate through 1) study or research for technological solutions, 2) expert exchange programmes between firms and universities, and 3) research/innovative financial support to develop new technology. The other model is that 4) the firms might collaborate through a revolving organization (TAI or TAPMA) which acts as collaborator between industry and universities by collecting common problems from firms and encouraging universities to find solution to given problems.

In term of the governmental support, there is minority of firms having the opinion that the government is active in clarifying national direction and policy to support cooperation, while the others (especially MNCs) do not.

The interviews make it clear that the universities, through necessity, have been developed to be training institutions. The universities' linkages to industry were not made through research and invention, but rather as a supplier of a trained workforce. Later, as research was added in to universities' mission through the national education policy, the traditional method of communication with industry was through publication and academic journals. In term of universities' roles, universities as a central players have two sides to serve in the collaboration with government, industry and other organizations/institutes;

- University as supplier

Universities are to serve the industry in the following areas:

- 1) Quality graduates relevant to industrial and social needs,
- 2) Research/knowledge/innovation,
- 3) Incubation services,
- 4) Technology transfer services,
- 5) Solutions to problems/challenges,
- 6) Management consultancy and training.

- University as demander

Universities require resources and collaboration with both government and industry to effectively serve the industry as mentioned above in the following areas:

- 1) Financial and equipment support,
- 2) Enterprise strategy to become entrepreneurial universities,
- 3) Technology transfer from MNC/JV firms,
- 4) Collaboration with firms for internship, cooperative programme, and laboratories/instruments.

In term of university-based research, the technological and product development from universities' research has not been impressive. Therefore if the Thai automotive industry succeeds in high technology areas in automobile equipment, there is a low level of contributions coming from Thai university-based researchers.

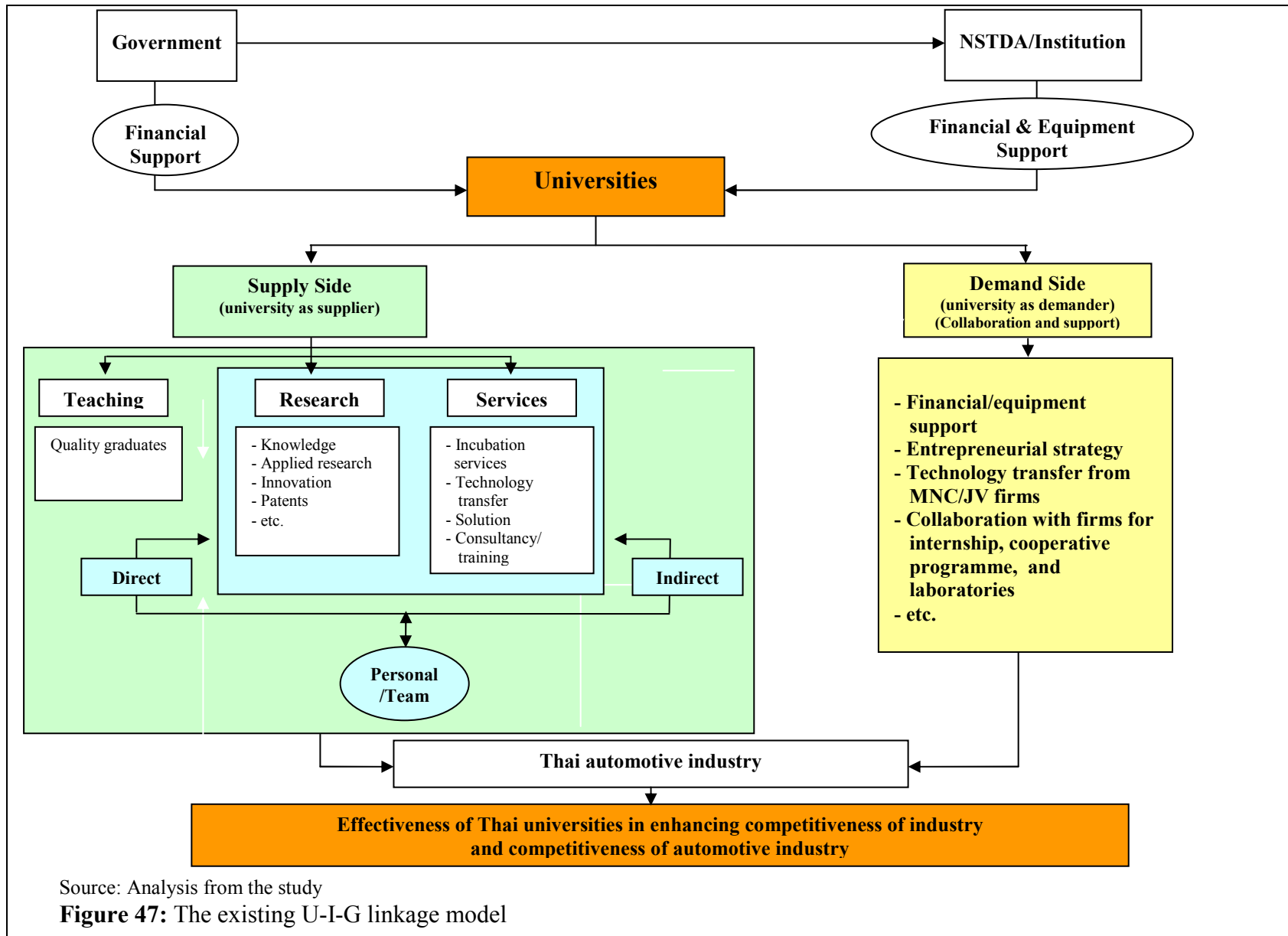
The industry's expectation of the universities was the supply of well-trained human resources, rather than the production of innovative inventions from scientific research. From the industry's perspective, the universities were the training centres to generate relevant workforce. Since firms did not receive economically valuable scientific knowledge from the universities, they adopted a strategy of either developing their own technology or importing cutting edge technology from advanced countries. Although this conception of the universities as the training centres may now be outdated, firms still see universities as ivory towers where professors are interested in openly publishing their research and have little interest in the needs of industry.

At present, the collaboration between the universities and industry in R&D is relatively weak. In cases that there has been such a relationship, the most common practices are simple monetary contributions from corporations to universities and informal collaboration, such as consulting services. Interaction between industry and the universities has largely been informal and personal. One significant reason for this is the rules and standards governing the universities and faculty members that do not favour the entrepreneurial exploitation of university-based research. The study can be summarized in two general findings. First, there are no formal research contracts, but abundant informal linkages. Second, there is a low level of long-term relationships.

An explanation for this lack of interaction is that there is no tradition of mutual trust. Firms believe that inventive activities should be performed in-house. They assume that universities do not conduct any research that might lead to commercializable inventions. This is combined with criticism of the direction and pace of universities' R&D. However, from the university researchers' perspective, industrial research is often considered neither creative nor challenging. To all intents and purposes, universities and industry have been operating in different worlds.

Thai universities remain with a low level of cooperation with the automotive industry, both auto-assemblers and auto-part producers. The universities' sampled comment themselves that they should produce graduates increasingly relevant to automotive industrial needs, while industry should support funding for research and innovation, and also cooperate to develop new technology. Moreover, government should have a clear policy direction to support automotive industry.

The existing collaboration between universities, firms, and government is shown in Figure 47.



We can summarize the weaknesses of the U-I-G relationships depicted above, which need to be improved, as follows:

- University
 - Universities cannot produce highly qualified and industrially relevant graduates due to the lack of equipment and industrially experienced faculty members;
 - Universities do not understand the nature of industry; so universities fail to find real industrial needs and their research outputs are not applicable;
 - Universities do not get sufficient funding from government and industry;
 - Universities do not seriously cooperate with other related sectors due to the lack of trust, incentive and institutional collaboration.
- Automotive industry
 - The industry are not interested in co-developing innovative research with universities because of potentially low short-term returns;
 - Assemblers have their own R&D; it is thus not necessary to cooperate with universities which are seen as lacking capacity and a corporate culture;
 - Most Thai auto-part firms' R&D is controlled by clients that are foreign companies, so there is no or only a low level of technology transfer and research cooperation for innovation;
 - There is a mismatch between industrial short-term needs for benefits and long-term returns from conducting research;
 - Only a few firms are interested in collaborating with universities (through projects, teaching and design of curriculum) in producing relevant graduates because they do not see it as cost-effective and do not want to give technical knowledge away.
- Government
 - Government does not have a clear long-term direction to support automotive industry due to internal politics, newly launched international free-trade agreements (e.g., FTA) and players' conflicts of interests;

- Government does not invest in automotive testing centres and an automotive one-stop-service agency;
- The government-sponsored industrial organization, Thailand's Automotive Institute, does not have sufficient funding and relies on national politics with the bureaucratic procedures of the ministry of industry.

Chapter 5

Discussion of Results and Findings

This chapter presents the analysis and discussion of this study of the relationship between universities and industry in the knowledge economy, taking the case study of Thailand's automotive cluster. The study applies the Triple Helix model of U-I-G relations for analysis and discussion. The chapter is divided into 2 parts:

- Development of Thailand's automotive cluster
- U-I-G linkage to upgrade Thailand's automotive industry and its innovation system

5.1 Development of Thailand's automotive industry

The development of the Thai automotive industry had been dependent upon import substitution policies. The interest, however, has shifted toward more liberalized policies to correspond with the current global trend. These policies include loosening tariff barriers, abolishing local content measures, promoting investment and exports, and also cooperating with international communities such as ASEAN, APEC and WTO.

The study finds that the Thai automotive industry's structure is similar to that of other countries such as Japan, Korea, Malaysia, and Indonesia. Such a structure embraces two major elements, namely auto assemblers and auto parts and components suppliers (classified by related-tier of production). Within Thailand's automotive industry, the first tier of the parts and components industry comprises an estimated 40% of companies with majority foreign ownership, 10% with majority Thai ownership, and 50% pure Thai companies, while most local firms (mostly small and medium enterprises) serve as second and third tier, and repair-parts producers, and after market producers.

The development of the Thai automotive industry originated with governmental policy to foster the establishment of a car production base from overseas into Thailand. This strategy aimed to develop the industrial workforce and obtain technology transfer.

Establishment of overseas auto assemblers in Thailand has encouraged the emergence of Thai (domestic) auto part manufacturing. Due to the lack of self-owned technology, Thai auto part production depends upon foreign technology such as that of Japanese and Western auto makers. Consequently, the Thai automotive industry is less interested in cooperation with universities that do not have relatively more relevant technology compared to that of foreign firms.

Comparing Thailand with Korea during this period, Korea was aggressive in obtaining technologies from abroad and using them as the basis for improving technology capabilities. For example, from 1962 to 1982 there were 2,281 technical and licensing agreements, of which 533 were with the US and 1,287 with Japan. Korean firms offered diverse incentives to foreign firms with innovative technologies, such as funding commercialization, facilitating local market access, and providing plants and equipment. They often sent researchers to US firms to expose them to advanced technology (Sohn, 2005).

Therefore, the term “technology transfer” is not always regarded as the flow of knowledge from the universities to industry; rather it - especially in developing countries, including this case of Thailand’s automotive industry - often refers to the transfer of technologies from advanced countries, such as US and Japan, to the domestic industry. The technologies imported from advanced countries have been largely employed by large firms. Technological alliances with world market leaders allow the large firms to penetrate new markets faster and give them access to a broader range of cutting-edge technology (ibid).

Reflecting the emphasis on labour intensive production during the early phase of development of Thailand’s automotive industry, universities mostly serve industry through generating knowledge workers and consultancy by personal contact. Some

experts from universities obtain financial incentives from external consultancies; they thus leave teaching and turn to working for industry.

At the beginning of Thai automotive development, the industrial driving force is an interaction between governmental and private sectors. Universities are only serving industry as knowledgeable graduates' production units. The early stage of Thai automotive industry's development is, however, broadly similar to that of Korea, Malaysia and Singapore.

5.2 U-I-G linkage to upgrade Thai Automotive Industry and Automotive Innovation System (TAIS)

1) Technological capacity

In the Thai automotive industry, the study shows that technology and new management strategies can be efficiently transferred from the parent companies to their JV companies. The support from the parent companies normally takes the form of high technology machines, research activities, and development programmes to continuously improve products and production quality. Some local part manufacturers have Technical Assistance (TA) agreement with foreign companies, in which foreign companies offer technical support on a product-by-product basis. PT companies are Thai manufacturers without any support from foreign companies. However, many of the PT companies have turned into JV and TA companies due to the financial crisis and inadequate technical capability. Some of the remaining PT companies have opted for foreign technical support to improve their technical know-how.

PT companies are only effective for manufacturing parts for which high technology is not required; this condition resembles the Indonesian case (Nag, *et al.*, 2007). Costs in these companies are relatively low owing to the less-expensive production technology requiring inexpensive machines and low salaries for workers. Although most of the PT companies deliver good quality products, some others might not meet a global quality standard because of their outdated technology and managerial problems.

The overall scene of technological capacities in the Thai manufacturing sector is as follows. A few capable foreign-affiliated and some Thai-owned companies (mainly larger ones) have acquired intermediate technological capabilities in product design or process improvement. Most local small and medium-sized enterprises (SMEs), however, have only adaptive capabilities (Arnold, *et al.*, 2000:78). Affiliates of multinational companies in Thailand are mainly manufacturing arms that are not extensively tied with the local economy, meaning that new technologies are imported from abroad and deployed without a transfer of competences to the host, not even for minor changes or maintenance (Dietz, 2001:4).

According to the study's findings, MNC and JV companies are not interested in cooperation with local research institutes and universities, but a few of them have a vision of upgrading Thailand's higher education. In those cases, the knowledge flows from industry to university. Meanwhile SMEs might have higher needs for externally acquired services due to limited in-house resources. Some of these micro-enterprises are lacking basic absorptive capacities and financial resources. If they cooperate with universities, the level of sophistication is expected to be relatively low and associated costs often require subsidy through government programmes. After all, peculiarities of Thai business culture also have an impact on cooperation. All larger companies and many SMEs are owned by Chinese-related families; in that respect, Thai entrepreneurialism is similar to that of Taiwan and others with a critical mass of Chinese (EAU, 1995). U-I linkages and firms' management are affected because there is a closed network of these companies mostly comprising family members (Intarakumnerd and Panthawi, 2003: 44). Recently, this picture of industry is changing since the younger generation of the owning families graduated from Thai universities, making them more open toward co-operation with universities.

In terms of technological capability formation, theoretically, firms could improve their productivity in several ways, such as 1) acquiring new machinery (newer models of machines which are technologically more sophisticated); 2) in-house training efforts such as training or technological activities; 3) the accumulation of employees' experience (the learning-by-doing effect); 4) the hiring of skilled workers from other companies; 5) technical assistance resulting from having a relationship with clients

(inter-firm relationship with customers); 6) the improvement of the quality of the suppliers (inter-firm relationship with suppliers); and 7) technical linkages with institutions in Thailand (domestic sources of technology) (Techakanont and Terdudomtham, 2004).

The study of Techakanont and Terdudomtham (2004) displayed that in-house efforts and the accumulated experiences of employees were regarded as the most important sources of technological improvement, as also shown in this study. It is interesting to observe that those improvements came from their suppliers, inter-firm technical relationships with customers, and the adoption of new machines that were expected to have a strong impact. Technical linkages with institutions in Thailand, such as universities, government laboratories, or technical training institutions were found to be less important to foreign and JV firms than they were to Thai firms. This case resembles Malaysia and Korea (Saad *et al.*, 2005 and Ravenhill, 2004) in that most foreign companies conduct their R&D in the home country and thus do not see the need to collaborate with local higher education or research institutions to undertake joint R&D to improve their product performance.

This finding provides evidence to support the argument that firms with foreign ownership have considerable opportunities to obtain the necessary technology (both for manufacturing and for improving productivity) from their parent companies. Such opportunities are not available to Thai firms; therefore, it is not surprising to observe that a domestic source of technology is regarded as an important source of technological improvement for independent Thai-domestic firms.

2) Universities in the innovation system

Nelson (1993) and Lundvall and Johnson (1994) state that a process of innovation implies close linkages among different units within an enterprise, with other enterprises, company-oriented service providers, public research institutions, and universities. Within innovation systems, interactions between these players are guided through both formal and informal rules (Edquist 1997; Freeman 2001). The nature

and intensity of the interactions that go on between players crucially influence the innovative performance of the enterprises that belong to a given innovation system.

The study by Gibbons *et al.* (1994) found that new forms of universities evolved owing to the establishment of technology-transfer units, the creation of incubators for technology-based enterprises, and the establishment of science parks. Universities transform themselves into entrepreneurial universities (Clark, 1998), their capability to transfer technology to enterprises increases, which leads to partial superposition of the functions of universities and enterprises in a process of innovation.

However, Schiller (2006) argues that these frameworks have to be modified for the study of innovation systems in developing countries. Innovation systems in countries like Thailand can better be described as “learning systems”. The role of universities in learning systems is not to generate new knowledge but to raise the skills of the population - i.e. to build up human capital - and to help absorb ideas from developed countries (Mathews, 2001; Viotti, 2002). Overall technological development in learning systems, which can only be achieved by the successful absorption of knowledge, is determined by the absorptive capacities of the national firms. A firm can enhance its absorptive capacity through training its personnel, carrying out R&D, and deploying advanced manufacturing equipment. Thus, an existing absorptive capacity and additional learning efforts mutually reinforce each other (Asheim and Vang, 2004; Cohen and Levinthal, 1990).

This study’s finding is similar to Schiller’s paper (2006) that universities and the automotive industry have low levels of collaboration because most of the Thai auto-part firms’ R&D is controlled by clients that are foreign companies; technology transfer and research cooperation for new innovation are thus on a rather small scale. Therefore, universities are inhibited from achieving the highest potential of furthering industrial innovation and rather focus on the objective of producing graduates increasingly relevant to industrial needs and conducting their own research of interest. However, the in-depth interviews also reveal that Thai universities attempt to achieve their new roles of supporting science and technology development especially in national major industries such as the automotive industry through the establishment of

technology-transfer units, creation of incubators for technology-based enterprises, and establishment of science parks. Many universities seek to transform themselves into entrepreneurial universities.

3) U-I-G linkages in Thai automotive industry

During Thailand's eighth economic and social development plan (1997-2001), the government began to advocate that Thai universities develop better linkages to local industry. Thai policy makers have then considered policies to encourage U-I linkages, as the existing U-I linkages were no longer considered sufficient. Reflecting this concern, since the early 1990s, the U-I cooperation has become a centre of public policy debate. In response to the argument, many universities were driven to create technology transfer units. For example, Chulalongkorn University established its Intellectual Property Institute (CUIPI) and Scientific and Technological Research Equipment Centre; King Mongkut's Institute of Technology North Bangkok founded its Science and Technology Research Centre and Thai-French Innovation Centre; and Suranaree University of Technology established its Cooperative Education Programme.

The early phase of Thai U-I linkages formally encouraged through governmental policy is somewhat similar to that of Korea, Japan, and Malaysia. At the same period as the Thai government considered U-I linkages, Korea underwent economic reforms, of which one, passed in 1998, was the "Special Entrepreneurship Act." The Act was meant to foster entrepreneurship for building high technology industries through technology transfer from the university to industry. In response to the Act, the Ministry of Education revised the laws governing the activities of academic researchers to allow business activities that did not interfere with their obligations. Many of the restrictions that limited the interaction of academic researchers with industry were either eliminated or loosened. Universities were urged to create organizations to manage technology transfer. For example, the establishment of Technology Transfer Offices (TTOs) to handle patenting and licensing of university inventions was authorized. Simultaneously, most universities also started to establish

new incentive systems to encourage their faculty to file patents through their TTOs (Sohn, 2005).

In Japan, the Science and Technology Basic Law was passed by the Japanese parliament in 1995, and the first Science and Technology Basic Plan (1996-2000) was launched. This emphasized an increase in the Science and Technology budget, and enforced links between universities and industry. Subsequently, and as a consequence, the Japanese research system has undergone rapid transformation.

Similarly to Thailand, Korea, and Japan, the Malaysian government has introduced various measures to strengthen university-industry links since 1991. Two major measures are 1) providing public funds to encourage collaborative research between universities and industry; and 2) strengthening the role of business units at universities to promote interactions with industry. Universities in Malaysia have then established various mechanisms and instruments to facilitate the links with industry, especially in the area of technology transfer and commercialization of research results. One noticeable effort is the setting up of university investment arms or business units to allow private enterprises to utilize a university's market expertise, skills and technology. A good example is Unisains Holdings Sendirian Berhad (Unisains) formed in 1997 by the Universiti Sains Malaysia (USM) in Penang. Two additional units to complement and work together with Unisains were established by USM in April 2002 and are known as the Engineering Innovation and Technology Development (EITD) unit and Medical Innovation and Technology Development Unit (MITD). Besides, the Malaysian government has launched the National Innovation Agenda with a focus on market-driven research aimed at promoting Malaysia's competitive advantage and harnessing intellectual capital in science and technology. The government has also drawn up various plans and programmes to enhance commercialization of research deriving from local universities and research institutes. Moreover, plans providing incentives to scientists and researchers from local universities are in the pipeline. The incentive package includes entitling scientists and researchers to partial ownership of the intellectual property, increasing research funding and providing incentives to establish collaboration with foreign universities (Saad, *et al.* 2005).

Despite the Thai government having launched policies to push universities to support automotive entrepreneurs through technological development and funding to related organizations, research institutes and universities, the relationship between universities and the automotive industry remains at less than a moderate level. Most of such relationships are through personal contact with academic experts. However relatively large PT companies (such as Thairung Union Car Public Co., Ltd. and Thai Summit Group) have their own R&D units to develop solutions/technology, similar to that of MNCs (for example, Toyota Motor Thailand Co., Ltd). Comparing this with other newly industrialized countries (NIEs) such as Korea, universities and research institutes were recognized as much more important sources of information by Korean companies than by Thai companies. Table 17 shows that Thai firms recognize the importance of universities and research institutes as sources of information for innovation activities although only 35.8% and 29.5% respectively of innovation were attributed to these sources, while Korean firms recognize up to 53.6% and 52.6% respectively.

Table 17: Comparison of Thai and Korean sources of innovation development

<i>Thailand</i>	<i>Percentage</i>	<i>Korea</i>	<i>Percentage</i>
Clients	77.4	Customers	77.7
Internet	63.0	Competitors	69.3
Parent/associate companies	61.1	Exhibition	65.5
Locally-owned suppliers	59.9	Internet	64.9
Specialist literature	55.6	Component suppliers	61.7
Professional conference and meetings	55.2	Patent	59.8
Foreign-owned suppliers	54.8	Equipment suppliers	57.7
Fairs and exhibitions	53.1		
Competitors	42.1		
Technical service providers	40.2		
Universities/higher education institutes	35.8	University/higher education institutes	53.6
Business service providers	33.1	Enterprises within the group	52.9
Patent disclosure	32.0	Public Research Institute	52.6
Government/private non-profit research institutes	29.5	New personnel	51.9
		Trade associations	44.2

Source: Thailand R&D/Innovation Survey 2002 and Korea Innovation Survey 2002.

In 2003, Mahidol University's College of Management investigated and summarized the gaps in Thailand's industry-academia collaboration, demonstrating weaknesses on both sides that obstruct meaningful collaboration (Table 18). Most items from Mahidol University's findings are found again in the case of universities and industry in Thailand's automotive industry.

Table 18: Gaps in industry-academia collaboration

Industries	Gaps	Academia
<ul style="list-style-type: none"> Passive actors 	<ul style="list-style-type: none"> Lacking continuous cooperative projects of activities and motivation for collaboration 	<ul style="list-style-type: none"> Major activities are not two-way cooperation. Education institutes usually initiate and dominate the relationship
<ul style="list-style-type: none"> No tangible/substantial activities that might lead to collaboration with education institutes 	<ul style="list-style-type: none"> Clear goals and objectives of the collaboration are missing Lacking mediators who can understand both sides, coach, and foster the relationship Lacking analysis of Problems from the Industry's perspective 	<ul style="list-style-type: none"> Linkages are more in terms of asking for help than achieving the project together for maximum benefit of both parties No substantial linkages in term of R&D projects

Source: College of Management, Mahidol University (2003)

Regarding the expected benefits of clustering from coopetition among players enhancing industrial competitiveness, geographical proximity of university and firms

in Thailand's automotive cluster is rather insignificant in promoting such university-industry linkages. This finding is similar to Vedovello's study (1997) that finds no evidence of significance in promoting linkages between host university and firms within Surrey Research Park (U.K.) and Western Australia Technology Park (Australia). However, informal and human resource links may be enhanced through proximity even though formal linkage has not been strengthened.

For the areas with high levels of formal cooperation with universities, firms employ university consultancies, internship of science and technology undergraduates, and research contracts. Firms have rather less cooperation in developing products/instruments, financing research/innovation, financing scholarships for science and technology undergraduates and cooperating for incubation services. Firms have informal collaboration with universities through personal contacts with academic staff, access to training courses, participation in seminars/conferences, engineering consultancies, and access to research.

Comparing this with Schiller's study (2006), Schiller found that modes of U-I linkage in Thailand are mainly limited to services without in-depth research involvement and linear modes of knowledge transfer. Half of the U-I linkage projects in Thailand comprise consulting services. Technical services (e.g. testing of samples) and informal contacts are the second most critical modes of co-operation. Thus service-oriented U-I linkages could be considered linear modes (licensing, sales, and contract research). The third most essential linkage is based on teaching (internship and training). Research activities resulting from cooperation (e.g. joint research) are accounted for less than 10% of the U-I cooperative projects. The results are in line with a less extensive study conducted by the Brooker Group (1995:46).

According to Sohn's (2005) study of Korea, formal research contracts between universities and industry in Korea have also been limited. Informal linkages have been rather strong, and they are an important conduit for the transfer of knowledge from university to industry. Sohn explained that a good example of the informal linkages is the faculty consulting that serves as a linkage when the formal connections are not functioning well. The consulting connection is usually based on personal

relationships. Because of the high informality, consulting can be much more flexible and less-structured than contracted research. The result of this study is similar to the revelations in in-depth interviews with Thai universities that most universities and industry have preferred informal collaboration through personal contact.

In Thailand nowadays, the collaboration between the universities and industry in R&D remains relatively weak. In cases where there has been such a relationship, the most common practices are simple monetary contributions from corporations to universities and informal collaboration such as consulting services. Interaction between industry and the universities has largely been informal and personal. One significant reason for this is the rule and standards governing the universities and faculty members that do not favour the entrepreneurial exploitation of university-based research. This study can be summarized in two general findings. First, there were few formal research contracts, but abundant informal linkages. Second, there was a low level of long-term relationship/commitment between university and industry.

The technological and product development drawn from research by Thai universities has not been critical. Therefore, there is rather a low level of contribution coming from Thai university-based researchers even if the Thai automotive industry were judged successful in high technological areas in automotive equipment.

The result of the automotive industry's expectation toward Thai universities is the concern in Lee's (2002) study. The industry views and expects the universities to be the generator of relevant workforce, rather than the producer of innovative research. Companies then adopted a strategy of either developing their own technology or importing new technology from advanced countries since they did not obtain economically valuable scientific knowledge from the universities. The industry has remained the perspective that university professors are only interested in publishing research that meets their own interests, without much consideration of the industrial demands.

An explanation for this insignificant level of cooperation is that it results from the lack of mutual trust. This inference aligns with the work of Karpsoo *et al.* (2000) and Schiller (2006). Schiller's research found that both industry and universities are playing the blame game, with limited knowledge about potential partners while a lack of trust and communication seem to be the underlying barriers against co-operation. Academia often thinks that companies do not want to cooperate with them because they neither trust their industrial partners nor receive a grant before they have successfully finished a project. Others blame a lack of local industrial partners in academia's fields of research, while MNC companies are not interested in working with Thai universities. Private companies' perception of Thai universities is that universities usually do not have applicable/commercializable results and advanced equipment. Moreover, many firms believe that inventive activities should be performed in-house, as they assume that universities do not conduct any research that leads to commercialized inventions. This is combined with criticism of the direction and pace of universities' R&D. In university researchers' opinion, industrial research is often neither creative nor challenging. For all intents and purposes, universities and industry have different perspectives and views on the possibility and potential values of relationships.

Such an unsuccessful relationship, caused by low levels of confidence, mutual trust and interest among players, was found again in this study. The major automotive companies (such as Toyota Motor Thailand Co., Ltd., Thairung Union Car Public Co., Ltd., and Somboon Advance Technology Co., Ltd.) have closely cooperated with only their members or suppliers, while having different levels of linkage with universities depending on the level of trust. The automotive industry is aware of the low level of trust that industry generally has for Thai universities. The reason is that most firms have believed that universities can not produce relevant graduates to serve industry's need, most universities lack high-level technological knowledge to support industry, and faculty members specialize only in academic knowledge and can not apply their knowledge to solve industrial problems. Their suggestion is that universities should develop themselves to gain more confidence/trust; for example, universities should improve pedagogy/curriculum (through instruments such as cooperative education programmes with industry, entrepreneurial education, lecturers and curriculum

designer from industry, etc.) to generate graduates who will increasingly meet the needs of industry. Furthermore, government should collaborate with industry and universities to specify policy direction and support to enhance the competitiveness of industry.

However, the major challenge for the Thai automotive industry's competitiveness is found to be the shortage of skilled workers as engineers, technicians, and supervisors, similar to that of Malaysia (Saad *et al.* 2005). The major reasons are 1) there is a lack of fruitful linkages between universities and automotive companies, such that there is a mismatch between graduates' skills and companies' requirement; 2) there is a weak technical skill base of workers as a product of the education system emphasizing less on technical education; 3) the foreign workers can be hired to fill some of the skills gap, but the legal requirements of the hiring process for foreign workers are overly bureaucratic.

From the survey research, most firms expect to benefit from collaboration with universities in human resource development and technology/process development. In addition, firms' advice on collaborative relations between firms and universities is that they should directly collaborate through 1) study or research for technological solutions, 2) expert exchange programmes between firms and universities, and 3) research/innovative financial support to develop new technology. The other suggested model is that 4) the firms might collaborate with universities through an intermediate organization (TAI or TAPMA) which plays the role of a collaborator between industry and universities through collecting common problems from firms and distributing these to universities to find solutions.

Thai university informants in this study comment themselves that they should produce graduates increasingly relevant to automotive industrial needs, while industry should support research and innovation through funding, and also cooperate to develop new technology. Moreover, government should have a clear direction to support the automotive industry.

Even if Thai universities perform their traditional roles, they are also taking on new roles, such as that of entrepreneurs. University entrepreneurship takes various forms, including establishing organizational mechanisms such as technology transfer offices, incubator facilities or students' start-up companies, and business units to offer consulting advice to micro-firms who are at the beginning stage of raising their level of expertise, similar Etzkowitz's (2003) account. In the Triple Helix model, each helix, including universities, acts as a hybrid organization. Universities with their third mission in economic development started operating their hybrid units such as technology transfer office and incubator facilities; while government provides financial and infrastructural supports for innovation and helps improve the environment for innovation. Universities and the automotive industry are engaging in such cooperation promoted by intermediate organization supporting technology transfer and incubation projects.

4) Governmental institutes / agencies

(1) Thailand Automotive Institute (TAI)

To improve the global competitiveness of the Thai automotive industry, the Ministry of Industry established Thailand Automotive Institute (TAI) as the principle organization responsible for the following:

- *Conducting any research necessary for the formulation of suitable policies, and taking a coordinating role in facilitating the country's continuous automobile industrial development;*
- *Preparing master plans for the development of Thailand's automobile and plastic industries, as well as comparative facts on the automobile industry. This is to create business competitiveness in domestic and international trade;*
- *Assisting the country's spare parts manufacturers in developing their production technology forwards international standards;*
- *International capacity building: facilitating the development of human resources in the automobile industry;*

- *Establishing national spare parts standards and providing inspection and testing services for spare parts certification;*
- *Developing Thailand's automobile and spare parts testing centre;*
- *Applying latest techniques to enable Thailand's automobile industry to develop in terms of technology and quality.* (Source: www.thaiauto.or.th)

The scope of public services consists of providing training seminars and information services, providing advice related to the automobile industry, and testing automotive products and spare parts. The role of TAI to bridge universities and industry is rather in-explicit. TAI, as the central organization, is to promote linkages of Thai universities and automotive industry to enhance more U-I cooperation especially in development of technology, management, and quality of industrial staff. Through incentives, TAI will urge academic staff and experts from universities to conduct research together with automotive companies for enhancing quality control and technology development for better qualified and standardized components relevant to customers' need. However, insufficient funding and bureaucracy and politics under the ministry of industry inhibit TAI from assuming an effective role.

In the Triple Helix model for innovation systems, similarly to universities playing roles of hybrid organizations, the government sets up infrastructures for innovation, helping establishment of an innovative environment, and even provides loan assurance for R&D through TAI as a governmental hybrid organization. Universities and the automotive industry are encouraged by TAI to engage in new cooperation. The overlapping of the three helixes involves the creation and dissemination of knowledge leading to innovation can be effective only with the support of government through policy and initiatives.

(2) Thailand Science Park

The Thai Royal Government has established the Thailand Science Park (TSP) and it commenced operation in 2002 as a fully integrated hub for R&D in science and technology. It is under the management of the National Science and Technology

Development Agency (NSTDA). Its missions are to promote innovation and R&D activities in the private sector and to develop a critical mass of R&D human resources for Thailand. TSP houses NSTDA's headquarters and four national research centres with state-of-the-art equipment on its premises. These national research centres are:

- National Centre of Genetic Engineering and Biotechnology (BIOTEC);
- National Metal and Materials Technology Centre (MTEC);
- National Electronics and Computer Technology Centre (NECTEC);
- National Nanotechnology Centre (NANOTEC)

Government-sponsored research institutes, including BIOTEC, MTEC, NECTEC, and NANOTEC, could also be viewed as governmental hybrid organizations as they perform different roles (such as conducting research, starting up spin-offs, training, conducting studies on supporting policies), while pursuing the tri-lateral network among university, industry and government.

According to the informants from Thai research institutes and revolving organizations, the organization and industry linkage is at a moderate level, while organizations and universities linkage is at a low level. This is because many firms are members of those organizations, while most university faculty members are not associated with the respective organizations. A key factor that makes respective organizations unable to successfully push the industry-universities linkage is that most of the related organizations lack sufficient funding to support and some do not have a mission to promote such linkages. Most automotive organizations suggest that universities, industry, and government should work together to promote the effective linkage for industrial competitiveness.

Chapter 6

Conclusion and Recommendations

This chapter presents conclusions and recommendations derived from this study of the relationship between universities and industry in the knowledge economy featuring the case study of Thailand's automotive industry.

6.1 Conclusion

To further develop the competitiveness of Thai automotive industry, universities have two roles to serve the Thai automotive cluster, in collaboration with government, organizations/institutions, and industry;

- University as supplier

Universities are expected to serve the industry in the following areas:

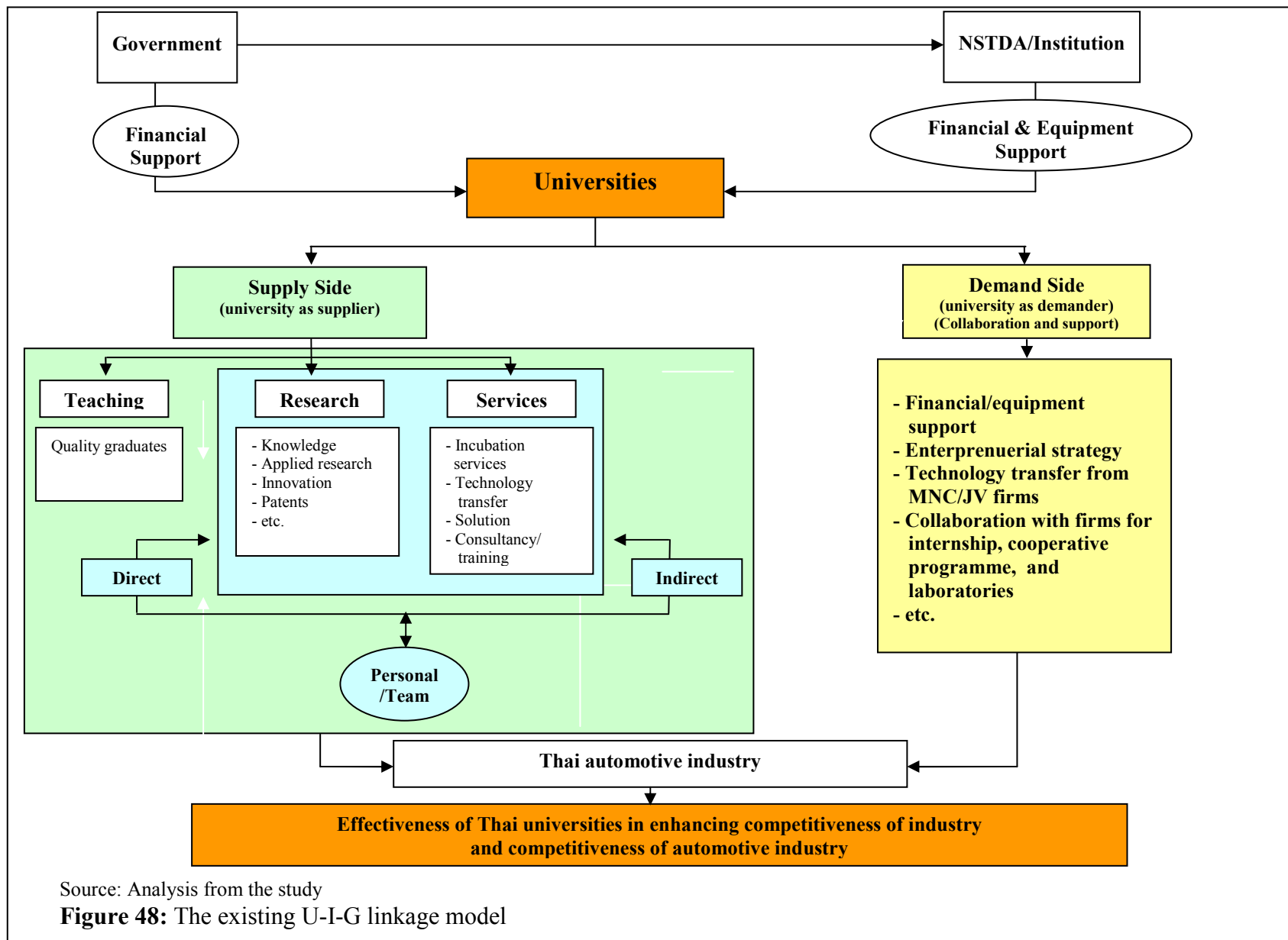
- 1) Quality graduates relevant to industrial and social needs,
- 2) Research/knowledge/innovation,
- 3) Incubation services,
- 4) Technology transfer services,
- 5) Solutions to problems/challenges,
- 6) Management consultancy and training

- University as demander

Universities require support and collaboration with both government and industry to effectively serve the industry as mentioned above in the following areas:

- 1) Financial and equipment support,
- 2) Enterprise strategy to become entrepreneurial universities,
- 3) Technology transfer from MNC/JV firms,
- 4) Collaboration with firms for internship, cooperative programme, and laboratories

The U-I-G linkage in Thailand exists under a tri-lateral relationship, as shown in Figure 48.



Regarding the direct relationship between university and industry above, there is a wide gap between the absorptive capacities of private companies and knowledge production of universities because of technological and capacity constraints on the part of both partners, as mentioned earlier. The majority of Thai universities remain focused on undergraduate teaching. Only a few public universities have taken steps to transform themselves into research universities, while most Thai companies are not interested in R&D and do not demand sophisticated academic services.

According to the indirect relationship through TAI as a coordinator and a hybrid organization of the U-I-G linkage, the study finds that TAI have not successfully developed effective bonds among actors. This results from TAI continuing to play an insignificant role in coordination between the educational and industrial sectors. TAI only identifies parties in university and industry whilst putting them in contact, without supporting any operation and support schemes to tighten U-I linkages. Moreover, TAI emphasizes only policy research, not explicitly devoting itself to the field of technical engineering research.

Thus the underdeveloped U-I-G relationship within Thailand's automotive cluster is derived from the three parties, namely universities, automotive industry, and government. The weaknesses of the U-I-G relationship which need to be improved are summarized as follows:

- University
 - Universities cannot produce highly qualified and industrially relevant graduates due to the lack of equipment and industrially experienced faculty member;
 - Universities do not understand the nature of industry; so they neglect finding real industrial needs, and research outputs are not applicable;
 - Universities do not get sufficient funding from government or industrial support;
 - Universities do not seriously cooperate with other related sectors due to the lack of trust, incentive and institutional collaboration.
- Automotive industry
 - The industry is not interested in co-developing innovative research with universities because of potentially low short-term return;
 - Assemblers have their own R&D; it is thus not necessary to cooperate with universities, which are seen as not having capacity and corporate culture;

- Most Thai auto-part firms' R&D is controlled by clients that are foreign companies; so there is no, or only a low level of technology transfer and research cooperation for new innovation;
 - There is a mismatch between short-term industrial needs in benefits and long-term returns from conducting research;
 - Only a few firms are interested in collaborating with universities (through curriculum, projects and teaching) in producing relevant graduates, because they do not see it as cost-benefit effective and do not want to give technical knowledge away.
- Government
 - Government does not have clear long-term direction to support automotive industry due to internal politics, newly launched international free-trade agreements (e.g., FTA) and players' conflicts of interests;
 - Government does not invest in an automotive testing centre and an automotive one-stop-service agency;
 - The government-sponsored industrial organization, Thailand's Automotive Institute, does not have sufficient funding and relies on national politics with the bureaucratic procedures of the ministry of industry.

6.2 Recommendations

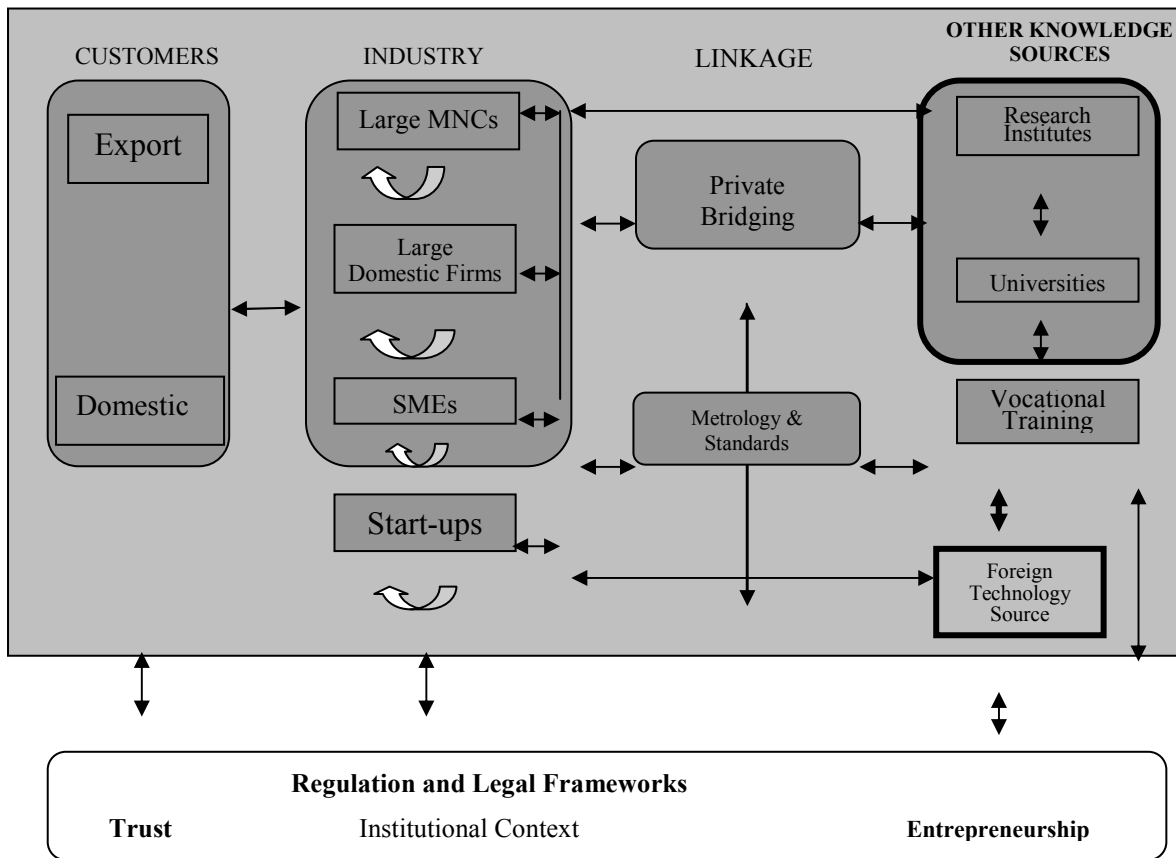
In Thailand, the existing U-I-G linkage model (Figure 48) is appropriate for the upgrading of the Thai automotive industry. It could be more effective only if some U-I-G mechanisms are adjusted to create more confidence, mutual trust and common interest among the three partners, while improving effectiveness and efficiency of units/mechanisms within.

From the study, the central issue that inhibits an effective collaboration of U-I leading to industrial competitiveness is the low level of confidence/mutual trust among players leading to low levels of coopetition among players caused by the lack of capacity and effectiveness of university in delivering to the expectations of industry, the low absorptive capacity of firms, firms' reliance on foreign technology and a government that lacks effective communication, clear direction/policy and an identified effective steering organization. Recommendations to further enhance fruitful

relationships between universities and the automotive industry in the knowledge-based economy are thus the following:

- 1) Where appropriate, universities that are interested in an industrial relationship should identify and expand their traditional missions (teaching and research), to the third mission of economic, social and industrial development.
- 2) To improve relationships and enhance confidence/mutual trust among universities, automotive industry and government, a set of recommendations is as follows:
 - Government
 - Government should have clear direction and communication to support the automotive industry;
 - Government should fully support the Thailand Automotive Institute to become the major supporter of industry by providing testing equipment, and block grants, together with a higher level of autonomy;
 - Government should establish a clear policy and a host agency on industrial clustering to enhance collaboration among players for competitiveness of the industry through exchange of information, technology/knowledge transfer, sharing of resources, collaborative research, and human resources development (through governmental tools such as incentives, grants and tax credit);
 - Government should provide financial and equipment support to universities operating industrial support units such as a technology transfer office, incubation unit, etc.
 - Universities

To establish the confidence of industry and expertise in the field, in addition to cooperation with domestic industry, universities may either establish partnerships with MNCs in advanced countries/foreign institutions in automotive engineering or send faculty members to gain experiences/skills from automotive MNCs, foreign institutions and other research institutes (Figure 49)



Source: Adapted from Arnold et al. (2000)

Figure 49: Relationship and partnership in an innovation system

- Universities must generate graduates increasingly relevant to the automotive industry's needs through cooperative education programmes, expert exchange programmes in teaching and curriculum designing, project-based learning with industry for technological solutions. These can be done through,
 - Finding out the real demands of the automotive industry and co-finding solutions to industrial problems,
 - Producing graduates with industrial capacity and problem-solving skills; teaching is expanded from lecture and discussion to a project mode in which participants exchange ideas and formulate a common objective, with teacher serving as facilitator,
 - Ensuring that teaching-learning reflect the skills needed in industry.

- Where appropriate, universities may embed entrepreneurial activities and spirit. This can be done through;
 - Developing incubation services and testing services to support Thai auto-part firms (SMEs);
 - Developing spin-offs and firms to further connect with industry and real world business while generating innovation;
 - Developing satellite campus/learning centres and programmes in the industrial cluster to understand the industry and serve it well;
 - Employing entrepreneurship education to train students and technicians to realize business and corporate value;
 - Educating the managerial workforce to manage organizations more effectively;
 - Developing technology transfer capability
 - Extending teaching from educating individuals to shaping organizations through entrepreneurial education and incubation;
 - Providing a supporting infrastructure for teachers and students to initiate new ventures with intellectual, commercial and conjoint characteristics.

- Universities should strengthen their research and innovation through,
 - Conducting research with identified commercial potential;
 - Identifying, promoting and working on specifically competitive research areas;
 - Establishing an entrepreneurial ethos on campus through policies on incentives and their enforcement;
 - Providing sufficient equipment and infrastructure for R&D;
 - Encouraging research-informed teaching and teaching-informed research.

- Universities might consider balancing and combining teaching, research and service to achieve their third mission (where appropriate and identified) through,
 - Developing a U-I unit such as a technology transfer office;
 - Encouraging faculty staff to support the work of the university and industry which, in turn, can generate income, etc.

- Universities should be aware of and consider technology patenting and licensing;
- Universities should encourage their faculty to provide consultation for industry to become experienced with problems and provide solution services to promote industrial competitiveness;
- Universities should reward staff who align and involve themselves with the university's policy to promote competitiveness of industry. With involvement with industry, industrial activities help compensate relatively a low salary for competent faculty staff. These schemes will also draw competent people into the university.

To achieve effective collaboration among government, institutes, universities, and the automotive industry, there are at least three models of cooperation to enhance the effectiveness and competitiveness of the industry.

Model 1: This model sets an intermediate organization supported by government as the bridge between individual firms and individual universities (see Figure 50 below).

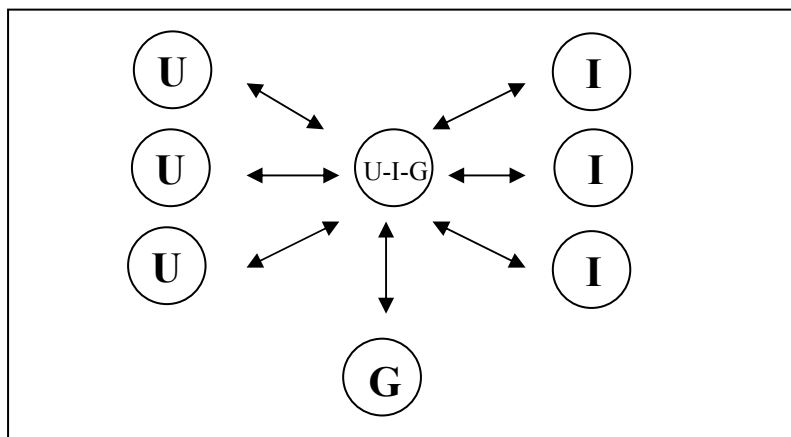


Figure 50: U-I-G Model 1

Model 2: This model encourages each group of firms and universities to cooperate and compete among themselves through association/organization while a governmental steering organization serves as coordinator and enhancer of such relationships (see Figure 51 below).

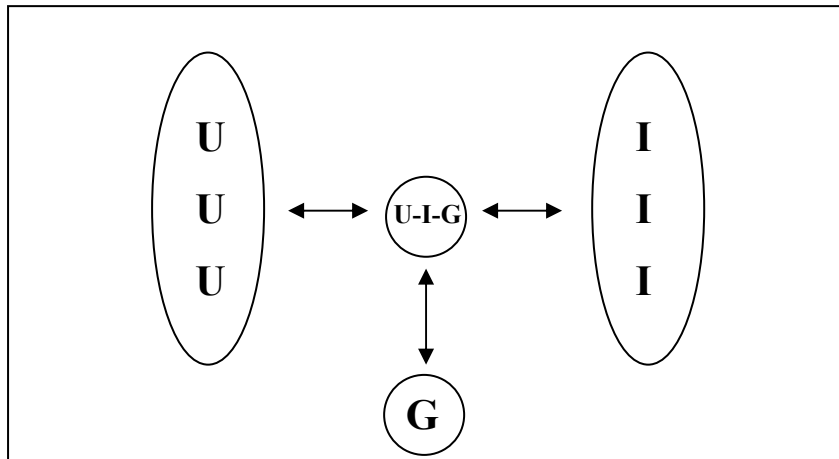


Figure 51: U-I-G Model 2

Model 3: Similar to the second model, this model encourages each group of firms and universities to cooperate and compete among themselves through association/organization while government supports each group to coordinate through supporting policies (see Figure 52 below).

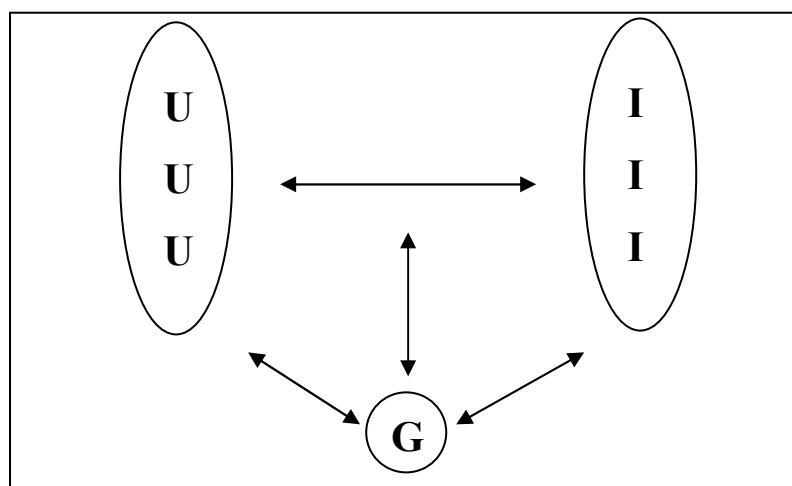


Figure 52: U-I-G Model 3

In Model 1 and 2, the intermediate organization comprising representatives from universities, industry and government is the centre of coordination and policy-making, while Model 2 and 3 emphasize the clustering of both universities and firms to enhance the benefits of coopetition among themselves. In the three models, government plays an important role in supporting the formation and effectiveness of a central agency while encouraging the establishment and operation of such clusters through policies, incentives, funding and other instruments.

According to the respective models above, government is recommended to operate on the basis of Model 2 as the following:

- 1) Government (for example the Commission on Higher Education, NSTDA, TAI) should establish an “Industry-University Cluster” with an executive body to support the automotive industry while driving TSAE to be a centre of universities’ cooperation;
 - In the industry-university cluster, government should establish and support a pooled resource centre for facility sharing and technology transfer;
 - Results of the industry-university cluster’s strategy can be identified as the result of coopetition in the following areas;
 - Human resource development,
 - Instrumental service,
 - Innovation research,
 - Exchange of information,
 - Technological transfer,
 - Bridge between players with complementary characteristics,
 - Shared-value and collaborative environment for collaboration;
- 2) A governmental intermediate organization (such as TAI) should be identified as the central organization that should be given greater autonomy and flexibility to support the coopetition of different players with greater efficiency and effectiveness.
- 3) Government and its intermediate organizations should employ more effective strategies in communicating their visions and strategic plans on the coopetition and linkages among players through incentives and instruments.

Universities will play their role as collaborators in the corporation-led model to strengthen more effective collaboration, through the different measures recommended above.

In this corporation-led model, government provides leading firms with support as an essential part of its industrial policy. The role of the university in this model is as a collaborator in firm's innovation, largely incremental in nature. Student projects, from BA to PhD research, focus on industrial problems and may be jointly supervised by company researchers who sometimes hold faculty status at university. In the corporate-led model, the science park typically provides a home for R&D units of firms whose remit is to organize universities' cooperative projects and recruit future employees. University departments and strategic units are to be developed to support specific industries.

In addition, the community of universities needs to improve its capacity in automotive engineering by forming an automotive engineering cluster to enhance their competitiveness and industrial relevance, through sharing resources/equipment, developing staff competences, creating shared-values, enhancing knowledge transfer, better positioning themselves in terms of their strength and policies (and possibly even geographically/physically) while interacting with industry.

This research acknowledges the challenges and difficulties in bringing about coopetition between universities and industry to achieve to raise the skill levels in industry's competitiveness. This study has shown a gap between companies' technological capacities and needs and universities' research and teaching. Only a few public universities have taken the step up from institutions of teaching toward research universities, while most Thai companies are not interested in R&D and do not demand sophisticated academic services since their R&D is controlled by foreign clients. In addition, universities and automotive companies agree that most universities have inadequate capacity and resources to effectively produce industrially relevant graduates and applicable research, while companies are not interested in long-term collaboration with universities due to their cost-benefit analysis being on a short-term basis. These have led to a lack of trust between the two groups of players. Moreover, government has not played an active role in clarifying their future vision of the industry, bridging different players in the value chain, and identifying a central organization to enhance the automotive industry's competitiveness with sufficient resources, flexibility and autonomy.

To achieve this, the government must promote a business environment of high productivity, through the improvement of the capability and productivity of local suppliers- particularly in the second and lower tiers. There is an identified niche technology of pick-up trucks (in which regional/domestic demand is strong and Thailand is currently the world's second largest exporter with the largest customized model variations) and recently small energy-efficient vehicles (eco-cars), for which Thailand has obtained commitments from Japanese assemblers to build in the country. Along with the Board of Investment's incentives to attract MNCs with priority activities, such as allowing duty-free machinery imports, land ownership rights and eight-year tax holidays, these niche market products offer Thailand's automotive industry an opportunity to further attract and engage with the MNCs.

Thailand's strong auto-part manufacturing offers a crucial advantage contributing to the industry's strength whilst giving the industry an edge over its competitors. In countries that do not have such an infrastructure, parts must be imported, contributing to the higher cost of vehicles. Since car assembly and first-tier production are controlled by MNCs and foreign suppliers with global networks and high levels of technology, second and third tier manufacturing for the mentioned niche markets is to be emphasized in order to create competitive edge in the industry.

To improve the capability and productivity of the auto-part industry to be competitive and attractive for MNCs, government-sponsored organizations (such as the Thailand's Automotive Institute) must play an active role to involve universities, research institutes, related organizations and key companies to develop human resource development programmes, a car-testing centre, and forums for automotive experts to establish sub-clusters of expertise and auto-parts manufacturing technology.

In addition, the government is recommended to provide MNCs with tax incentives and/or other possible benefits whilst giving universities financial support to establish expert exchange and development programmes, which might include cooperative projects and internships for students. These will enhance a stronger linkage and knowledge transfer between MNCs and universities. In addition, the Thai Automotive Institute must bridge local auto-part suppliers and universities through matching firms and universities for industrial solution-finding/R&D, consultancy programmes, training, expert exchange programmes, cooperative projects, and internship programmes. These initiatives for cooperation could lead to knowledge and skill transfers, universities' better

understanding of industrial needs, learning opportunities and cooperation to produce R&D and human resources serving the niche markets.

These new infrastructures will improve capability and competitiveness of the industry and its players. Local auto-part companies must be encouraged through government policies such as incentive schemes to produce higher value-added parts related to the identified niche markets, such as electronic fuel injection systems, moulds and dies, jigs and fixtures, anti-lock braking systems and substrates for catalytic converters to add more value to local production whilst furthering absorptive capacity and technical knowledge.

As an illustration of the application of the theory and findings in this study, please see Appendix H showing a study to develop Thailand's Technological University Model in which I recently participated for the National Education Council to consider policy and recommendation toward technological universities to make them more relevant to national and industrial demand for the country's greater competitiveness.

APPENDIXES

APPENDIX A

Automotive Part Manufacturers and Automotive Assemblers
in Samutprakarn's Automotive Cluster

APPENDIX B

Thai Universities with Mechanical
and/or Automotive Engineering Department

APPENDIX C

Development of Questionnaire

APPENDIX D

Questionnaire for Automotive Company

APPENDIX E

In-Depth Interview List

APPENDIX F

In-Depth Interview Schedule

APPENDIX G

Statistic Explaining Figure 19-46 in Chapter 4

APPENDIX H

Thailand's Technological University Model

APPENDIX A
Automotive Part Manufacturers and Automotive Assemblers
in Samutprakarn's Automotive Cluster

100 Automotive Part Manufacturers

1. Company Name : **Ampas Industries Co., Ltd.**
Address : 355 Moo4 Bangpoo Industrial Estate Soi 7, Sukhumvit Rd.,
Praeksa, Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-709-3868-70
Fax. : 662-324-0949
Website : -

2. Company Name : **Enkei Thai Co., Ltd.**
Address : 444 Moo 17, Bangplee Industrial Estate, Soi 6, Theparak Rd.,
Bangsaothong, King Aumphur Bangsaothong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-705-8060
Fax. : 662-705-8050
Website : www.enkeithai.co.th

3. Company Name : **Asia Precision Co., Ltd.**
Address : 79 Moo 2 Theparak Road, KM. 26, Bangsaothong, Bangsaothong
Sub-district, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-708-0407-11
Fax. : 662-708-0406
Website : -

4. Company Name : **Thai Metro Industry (1973) Co., Ltd.**
Address : 47 Moo 4 Soi Watsuansom Poochaosamingprai Road, Bangprong,
Muang, Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-383- 0376
Fax. : 662-383-0376
Website : -

5. Company Name : **Bangkok Spring Industrial Co., Ltd.**
Address : 112 Moo 2 Bangna-Trad KM.15 Rd., Bangchalong, Bangplee,
Sumutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-8570-80
Fax. : 662-312-5076
Website : www.somboongroup.com

6. Company Name :**Chaiyaparn Engineering Co., Ltd.**
Address : 278 Moo 10 Sukhapibal 1, Bangpleeyai, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-751-1448
Fax. : 662-751-0792
Website : -
-
7. Company Name :**DuPont Performance Coatings (Thailand) Ltd.**
Address : 4/4 Moo 8 Soi Wat Sriwarenoi, Bangna-Trad Rd., Bangchalong,
Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-734-5006, 662-752-2575
Fax. : 662-752-2578
Website : www.dupont.com
-
8. Company Name :**Thai Decal Co., Ltd.**
Address : 151/9 Moo 2 Soi Pukmit-Suansom Poojaosamingpai Rd., Samrong
Tai, Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-384-3419-21
Fax. : 662-384-1479
Website : -
-
9. Company Name :**Somboon Malleable Iron Industrial Co., Ltd.**
Address : 112 Moo 2 Bangna-Trad KM.15 Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-8570-89
Fax. : 662-312-5076
Website : www.somboongroup.com
-
10. Company Name :**Thaifujioka Co., Ltd.**
Address : 480 Moo 4 Bangpoo Industrial Estate, Soi 2, Sukhumvit Rd.,
Preaksa, Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-324-0905-6
Fax. : 662-324-0604
Website : -
-
11. Company Name :**Siam Kayaba Co., Ltd.**
Address : 380 Moo 2, Sukumwit Rd., Bangpoo Mai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-323-9035-6
Fax. : 662-323-9037
Website : -
-

12. Company Name :**Thai Summit Harness Co., Ltd.**
Address : 61/1 Moo 11, Soi Wilalai, Bangna-Trad Km.20 Rd., Bangchalong, Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-2605-7, 662-337-2365-9
Fax. : 662-337-2609
Website : www.thaiaummit-harness.co.th
-
13. Company Name :**Charoenlap Auto Part Co., Ltd.**
Address : 103/4 Moo 17, Soi Winners, Theparak Rd., Bangsaotong, King Amphur Bangsaotong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-315-2152, 662-330-3043-6
Fax. : 662-705-0670
Website : -
-
14. Company Name :**SNN Tools & Dies Co., Ltd.**
Address : 61 Moo 6, Bangna-Trad Km.32 Rd., Ban-Rakard, Bangbor, Samutprakarn Samutprakarn 10560, Thailand
Tel. : 662-337-6660-5
Fax. : 662-337-6657
Website : www.snnthai.thailandexport.com
-
15. Company Name :**Summit Steering Wheel Co., Ltd.**
Address : 92 Moo 14 Soi Kingtong, Kingkaew Rd., Rachatheva, Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-326-8632
Fax. : 662-326-8631
Website : -
-
16. Company Name :**K.K. Sparepart Co., Ltd.**
Address : 51 Moo 7 Kingkaew Rd., Rachathewa, Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-326-6414
Fax. : 662-326-7883
Website : -
-
17. Company Name :**Sang Charoen Tools Center Co., Ltd.**
Address : 912 Moo 15 Theparak Rd., Bangsaotrong, King Amphur Bangsaotrong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-313-1193-5
Fax. : 662-313-165600
Website : -
-

18. Company Name :**Siam Chita Co., Ltd.**

Address : 380 Moo 2, Sukhumvit Rd., Bangpoo Mai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-323-1191-2
Fax. : 662-323-1193
Website : -

19. Company Name :**Summit Auto Seats Industry Co., Ltd.**

Address : 62 Moo 12 Kingkaew Rd., Raxhatheva, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-3700-9
Fax. : 662-312-489000
Website : saggroup@asiaaccess.net.th

20. Company Name :**Armstrong Rubber & Chemical Products Co., Ltd.**

Address : 591 Moo 17 Soi Bangplee-Pattana Theparak Rd., Bangsaothong,
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-2021-3
Fax. : 662-315-2243, 662-315-2246
Website : www.armstrong.co.sg

21. Company Name :**T.S.K. Factory Co., Ltd.**

Address : 170 Moo 17 Bangplee Industrial Estate, Soi 4, Theparak Rd.,
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-315-1580-1
Fax. : 662-315-2826
Website : -

22. Company Name :**Thai Harnes Co., Ltd.**

Address : 61/1 Moo 11 Soi Vilalai Bangna-Trad KM.20 Rd., Bangchalong,
Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-2365-9
Fax. : 662-337-2609
Website : sw260199@loxinfo.co.th

23. Company Name : **Thai Yang Kitpaisan Co., Ltd.**

Address : 180/1 Soi Suksawasdi 74, Suksawat Rd., Bangkru, Phrapradaeng,
Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-819-1255-60, 662-463-0102
Fax. : 662-463-5198, 662-819-1261
Website : -

24. Company Name :**Srithai Auto Seats Industry Co., Ltd.**

Address : 569 Moo 2 Bangpoo Industrial Estate Soi 1B/1, Sukhumvit Rd.,
Bangpoomai, Muang, Samutprakarn Samutprakarn 10280,
Thailand
Tel. : 662-709-4445-7
Fax. : 662-324-0530
Website : www.asianvendors.com/Srithai

25. Company Name : **P.C. Products International Co., Ltd.**
Address : 44/2 Moo 1, Theparak Rd., Bangprieng, Bangbor,
Samutprakarn Samutprakarn 10560, Thailand
Tel. : 662-708-1442
Fax. : 662-338-1660
Website : www.pcproductsinter.com
-
26. Company Name : **Denso (Thailand) Co., Ltd.**
Address : 369 Moo 3 Teparak Rd., Teparak, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-394-0481, 027584646
Fax. : 662-758-4644, 662-758-4645
Website : -
-
27. Company Name : **S.Y.K. Spare Parts Industrial Co., Ltd.**
Address : 299 Moo 7, Soi Ruampattana 1 Poochaosamingpray,
Samrongklong, Phrapradaeng, Samutprakarn Samutprakarn 10130,
Thailand
Tel. : 662-756-9144-50
Fax. : 662-384-2729
Website : www.syk.co.th
-
28. Company Name : **T.S. Intertech Co., Ltd.**
Address : 4/3 Moo 1 Bangna-Trad Road Km.16, Tambol Bangchalong,
Aumphur Bangplee, Samutprakarn Samutprakarn 10540
Tel. : 662-740-6500-8
Fax. : 662-740-6509
Website : [www.Thaisummit.co.th/Ts group/tsit](http://www.Thaisummit.co.th/Ts_group/tsit)
-
29. Company Name : **Feltol Manufacturing Co., Ltd.**
Address : 476 Moo 4 Bangpoo Industrial Estate, Soi 2B, Sukhumvit Rd.,
Praksa, Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-709-3940-1
Fax. : 662-324-0614
Website : -
-
30. Company Name : **O.E.I. Parts Co., Ltd.**
Address : 926 Moo 15 theparak Industrial Estate Theparak Rd.,
BangsaoThong, Kingamphurbangsaothong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-706-0146-8
Fax. : 662-706-0149
Website : oeiparts@yahoo.com
-

31. Company Name : **CH. Auto Parts Co., Ltd.**

Address : 127 Moo 2 Soi Suansom, Poochao-Samingpray, Samrongtai,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-384-7358-60
Fax. : 662-384-1144
Website : -

32. Company Name : **C.M. Industry Co., Ltd.**

Address : 203 Moo 8 Soi Sukapibal 6 Poochaosamingprai Rd., Samrongtai,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-383-02967
Fax. : 662-383-0298
Website : -

33. Company Name : **Rosti (Mala) Ltd.**

Address : 370 Moo 8 Phuttaraksa Rd., Thaibandmai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-3871340-1
Fax. : 662-387-1351
Website : CLI@Rosti-MALA.com

34. Company Name : **Siam GS Battery Co., Ltd.**

Address : 78 Moo 3 Sukhumvit Rd., Bangpoo-Mai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-323-9030-2
Fax. : 662-323-9536
Website : qscom02@samart.co.th

35. Company Name : **Thai Automotive Industry Co., Ltd.**

Address : 73 Moo 2 Bangna-Trad Km.21 Rd., Srisajorakaeyai, King Amphur
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-312-8593
Fax. : 662-312-8266
Website : -

36. Company Name : **Far-Sight Sahakij Co., Ltd.**

Address : 1999/1 Moo 1 Soi Moo-Banpattanasouk, Tepharak Rd.,
Tepharak, Muang, Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-385-2127-31
Fax. : 662-385-2132
Website : -

37. Company Name : **Nissei Trading (Thailand) Co., Ltd.**

Address : 2056 Moo 4, Soi Sriboonruang 1 Taparak Rd., Taparak, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-758-4286-8, 0-2755-6201-2
Fax. : 662-384-1903, 662-384-1793
Website : www.nissei.co.th

38. Company Name : **A.A.A. Manufacturing Co., Ltd.**

Address : 2027 Moo 1 Soi MitUdom 1, Sukhumvit Rd., Samrongnua, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-396-1568, 662-399-0354
Fax. : 662-393-8425
Website : -

39. Company Name : **Inter-Hides & Leather Co., Ltd.**

Address : 678 Moo 2 Soi T.J.C. Sukhumvit Rd., Tambol Bangpoo-Mai,
Aumphur Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-323-2754-5
Fax. : 662-323-2749
Website : www.interhides.thailandexport.com

40. Company Name : **Siam Motors & Nissan Co., Ltd.**

Address : 76 Moo 1 Km.21 Bangna-Trad Rd., Srisajarakaeyai, Sub District
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-312-8443-55
Fax. : 662-312-8458
Website : -

41. Company Name : **S.P. Metal Parts Co., Ltd.**

Address : 37/24 Moo 3 Soi Kraisakdawat Teparak Rd., Bang-pa, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-7702-6
Fax. : 662-750-7701
Website : -

42. Company Name : **Thai Parkerizing Co., Ltd.**

Address : 570 Moo 4 Bangpoo Industrial Estate, Soi 12, Sukhumvit Rd.,
Praeksa, Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-324-6600
Fax. : 662-324-6687
Website : -

43. Company Name : **Thai Summit Autoparts Industry Co., Ltd.**
Address : 4/3 Moo 1 Bangna-Trad KM.16 Rd., Bangnachalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-0022
Fax. : 662-337-0273
Website : -
-
44. Company Name : **Precipart Co., Ltd.**
Address : 933 Moo 15 Teparuck Industrial Estate, Teparuck Rd.,
Bangsaothong, Sub District Bangsaothong,
samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-313-1474-5
Fax. : 662-313-1476
Website : -
-
45. Company Name : **New Somthai Motor Work Co., Ltd.**
Address : 73/1 Moo 4 Bangna-Trad Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-316-9324-31
Fax. : 662-316-9155
Website : -
-
46. Company Name : **Thai Chanathorn Industry Co., Ltd.**
Address : 61 Moo 11 Soi Vilalai Bangna-Trad Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-2305
Fax. : 662-337-2312
Website : -
-
47. Company Name : **Mahajak Industry Co., Ltd.**
Address : 210 Moo 10 Soi Tadsabansamrongtai 3 Poochaosamingpry Rd.,
Samrongtai, Phrapradaeng, Samutprakarn Samutprakarn 10130,
Thailand
Tel. : 662-384-2066
Fax. : 662-384-2105
Website : -
-
48. Company Name : **Bangkok Diecasting And Indection Co., Ltd.**
Address : 46/1 Moo 12, Bangna-Trad Rd., Bangplee-Yai Rd., Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-3078-84
Fax. : 662-337-3589, 662-337-3590
Website : www.bdi.co.th
-

49. Company Name :**Millenium Motors Co., Ltd.**

Address : 199 Moo 8 Phuttaraksa Rd., Taiband-Mai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-388-0868
Fax. : 662-701-4129
Website : -

50. Company Name :**Narong Industrial Public Co., Ltd.**

Address : 358-358/1 Moo 17 Bangplee Industrial Estate, Soi 7 Thapraruk
Rd., Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-315-3270
Fax. : 662-315-3275
Website : -

51. Company Name :**K.N.P. (1994) Co., Ltd.**

Address : 354 Moo 2 Soi Puthsee, Praeksa, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-703-6231-3
Fax. : 662-389-5890
Website : -

52. Company Name :**T S A Rubber Product Co., Ltd.**

Address : 180/1 Moo 1 Soi Suksawat 74 Suksawat Rd., Bangkru,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-819-1255-60
Fax. : 662-819-1263
Website : tsarubber@thaiautogroup.com

53. Company Name :**Thai Summit Mold Manufacturing Co., Ltd.**

Address : 4/3 Moo 1 Bangna - Trad KM.16 Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-0022
Fax. : 662-337-0273
Website : -

54. Company Name :**Thai Summit R&D Next Technology Co., Ltd.**

Address : 4/3 Moo 1 Bangna - Trak KM.16 Rd.,Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-0022
Fax. : 662-337-0273
Website : -

55. Company Name :**Metatech Co., Ltd.**

Address : 89/8-9-10 Moo 5 Srinakarin Rd., Bang Muang, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-703-6274-7
Fax. : 662-703-6272
Website : -

56. Company Name :**Somboonsiri Limited Partnership**

Address : 605/28 Moo 17 Soi Bangpleephattana, Thapharak Rd.,
Bangsaothong, Kingamphurbangsaothong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-705-2131
Fax. : 662-705-2132
Website : -

57. Company Name :**Cheowchan Industry (1989) Co., Ltd.**

Address : 84/4 Moo 8 Soi Sooksawat 74, Sooksawat Rd., Bangkru,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-463-4298, 662-819-1105-8
Fax. : 662-462-5562
Website : www.cci.co.th

58. Company Name :**Matsushita Electronic Components (Thailand) Co., Ltd.**

Address : 101 Moo 2 Tepharak Rd., Bangsaothong, Bangsaothong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-708-1111
Fax. : 662-708-0009, 662-708-0885
Website : -

59. Company Name :**Summit Auto Body Industry Co., Ltd.**

Address : 32-33 Moo 17, Bangna-Trad Rd., Bangplee-Yai, Bangplee,
Samuthprakarn Samutprakarn 10540, Thailand
Tel. : 662-316-8173 , 662-316-5001-7
Fax. : 662-316-8798
Website : -

60. Company Name :**United Coil Center Co., Ltd.**

Address : 54/10 Moo 7 Soi Tammasiri Bangna-Trad Km 25.5 Rd.,
Bangsaotong, Sub-Amphur Banagsaotong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-338-1340, 662-708-3170
Fax. : 662-338-1342
Website : -

61. Company Name : **NanoShield & Royal Ace Co., Ltd.**

Address : 261/61 Moo 2, Panwithee Rd., T.Bangpriang, Bangbor,
Samutprakarn 10560, Thailand
Tel. : 662-707-9931-3
Fax. : 662-708-5399
Website : www.welcome.to/pvd

62. Company Name : **Thai C.L.Industry Cable Co., Ltd.**

Address : 112/10 Moo 6 Soi Suksawat 76 Suksawat Rd., Bangjak,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-817-7700
Fax. : 662-464-1577
Website : -

63. Company Name : **Sooksawat Kolakarn Ltd.Part**

Address : 291 Moo 19 Soi Suksawat 39 Suksawat Rd., Bangphung,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-463-1700, 662-817-0124
Fax. : 662-463-3541
Website : sskco@asiaaccess.net.th

64. Company Name : **K.C.E. International Co., Ltd.**

Address : 677 Moo 4 Bangpoo Industrial Estate Sukhumvit Rd., Pheakkrasa,
Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-709-3156-62
Fax. : 662-324-0368, 662-324-0369
Website : -

65. Company Name : **Unit Parts Commercial Limited Partnerchip**

Address : 116/36 Moo 9 Soi sumsopol Taparuk Road Tambol Bangpra
District bangpee Samutprakarn 10280, Thailand
Tel. : 662-701-1657
Fax. : 662-701-1657
Website : -

66. Company Name : **Decho Mould & Die - Casting Co., Ltd.**

Address : 99 Moo 8 Watsri - Oon-Nuch Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-1281-8
Fax. : 662-337-1280
Website : www.dmd-group.com

67. Company Name : **B.K.J.Engineering Co., Ltd.**

Address : 71 Moo 3 Soi Bonkai Suksawad Rd., Bangchak, Phrapradaeng,
Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-464-2524-6
Fax. : 662-464-2528
Website : www.bkj.co.th

68. Company Name : **Katsuya (Thailand) Co.,Ltd.**

Address : 229/104-105 m.1 Teparak Road Tambol Bangsaothong District
Sub-District Bangsaothong Province
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-706-5915-6
Fax. : 662-706-5910
Website : -

69. Company Name : **Thai Storage Battery Public Co., Ltd.**

Address : 387 Moo 4 Bangpoo Industrial Estate Soi Phattana III Sukhumvit
Rd., Phaekkrasa, Muang, Samutprakarn Samutprakarn 10280,
Thailand
Tel. : 662-709-3535
Fax. : 662-709-4965
Website : tsb3k@ksc.th.com

70. Company Name : **Siam Fukoku Co., Ltd.**

Address : 900 Moo 15 Thapharak Rd., Bangsaothong,
Kingamphurbangksaothong, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-706-1018-9
Fax. : 662-706-1021
Website : kanit@siamfukoku.co.th

71. Company Name : **C.N.C. Parts Co., Ltd.**

Address : 106 Moo 7 Thapharak Rd., Thapharak, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-383-7457-8
Fax. : 662-383-5783
Website : -

72. Company Name : **Faratech Co., Ltd.**

Address : 59/11 Moo 5, Thapharak Rd., Bangplee - Yai, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-385-5094
Fax. : 662-755-3625
Website : -

73. Company Name :**M.N.Auto Part Co., Ltd.**

Address : 474 Moo 15 Thepharak Rd., Bangsaothong,
KingamphurBangsaothong, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-706-3092-4
Fax. : 662-706-3092, 662-706-3093
Website : -

74. Company Name :**T H A Coating Co., Ltd.**

Address : 440/1 Moo 14 Bangplee Industrial Estate Soi 6/1 Thepharak Rd.,
Bangsaothong, Kingamphurbangsaothong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-315-3577-8
Fax. : 662-315-3579
Website : -

75. Company Name :**Saha Autopart Industry Co., Ltd.**

Address : 33/29 Moo 10, Theparak Rd., Bangpla, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-6281-3
Fax. : 662-750-6280
Website : www.sahaautopart.com

76. Company Name :**Quality Coat Co., Ltd.**

Address : 1954 Moo 4 Soi Thepharak Thepharak Rd., Thepharak, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-334-4398, 662-384-5124
Fax. : 662-394-4398
Website : -

77. Company Name :**Thai Steel Service Center Ltd.**

Address : 47 Moo 7 Soi Watmachawong Poochaosamingpry Rd., Samrong,
Phrapradaeng, Samutprakarn Samutprakarn 10130, Thailand
Tel. : 662-398-0153-4
Fax. : 662-748-3842
Website : thaipiya@loxinfo.co.th

78. Company Name :**Thai Yamaha Motor Co., Ltd.**

Address : 64 Moo 1 Bangna - Trad Rd., Srisachoraklayai,
Kingamphurbangsaothong, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-740-8000, 662-740-8301
Fax. : 662-740-0977, 662-740-8099
Website : www.yamaha-motor.co.th

79. Company Name : **Thai Asahi Denki Co., Ltd.**

Address : 747 Moo 4 Bangpoo Industrial Estate, Sukhumvit Rd., Pheaksa,
Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-324-0380-2
Fax. : 662-324-0383
Website : -

80. Company Name : **CH. Watanayont Co., Ltd.**

Address : 77/1 Moo 14, Kingkaew Rd., Rachathawa, Bangpree,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-738-3501-5
Fax. : 662-738-3500
Website : -

81. Company Name : **Thai Summit PKK Bangna Co., Ltd.**

Address : 4/29 Moo 1 Bangna - Trad KM.16 Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-337-0364-9
Fax. : 662-337-0360
Website : -

82. Company Name : **C.H.Radiators Co., Ltd.**

Address : 5/3 Moo 14 Kingkew Rd., Rachatawa, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-738-9891-6
Fax. : 662-326-8301
Website : -

83. Company Name : **Murakami Ampas (Thailand) Co., Ltd.**

Address : 531 Moo 4 Bangpoo Industrial Estate Bangpoo Soi 9 Sukhumvit
Rd., Praksa, Muangsamutprakarn,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-709-4659
Fax. : 662-709-4658
Website : -

84. Company Name : **Thai Tech Die And Part Co., Ltd.**

Address : 615 Moo 15 Soi 41 Teparak KM.21 Bangsaothong, Subdistric
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-706-6001-4
Fax. : 662-706-3224
Website : -

85. Company Name : **Udom Pipatmongkol Limited Partnership**
Address : 613/1 Moo 4 Bangpoo Industrial Estate Soi 9 Sukhumvit Rd.,
praksa, Muang, Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-709-3412-4
Fax. : 662-324-0881
Website : -
-
86. Company Name : **TOA-Shinto (Thailand) Co., Ltd.**
Address : 31/1 Moo 3 Bangna-Trad Km.23 Rd., Bangsaothong, King
Aumphur Bangsaothong, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-740-0719-22
Fax. : 662-740-0718
Website : -
-
87. Company Name : **Shibata Giken (Thailand) Ltd., Part**
Address : 934 Moo 15 Taeparak KM.22 Bangsaothong, King
A.Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-706-1986-89
Fax. : 662-706-1990
Website : shibata.com
-
88. Company Name : **TTS Engineering Products Co., Ltd.**
Address : 99/9 Moo 8 Soi Big Fatr Teparak Rd., Bangpleeyai, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-312-3207-8
Fax. : 662-312-3208
Website : -
-
89. Company Name : **General Spring Center Co., Ltd.**
Address : 24/18 Moo 6 Soi 24 Land, Bangna-Trad Km 24 Road,
Bangsaothong Khing Amphur Bangsaothong
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-312-8612-6
Fax. : 662-312-8617
Website : -
-
90. Company Name : **C.S. Engineering Autopart Co., Ltd.**
Address : 69/7 Moo 6 Bangna-Trad Km.25 Road, Bangsaothong,
Bangsaothong Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-707-0747, 662-707-1834
Fax. : 662-707-0748, 662-707-1834
Website : -
-

91. Company Name : **NSA Industry Co., Ltd.**

Address : 109/123 Moo 2 Thaparak Road, Bangsaothong, Sub Amphur
Bangsaothog, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-708-0430-2
Fax. : 662-708-0433
Website : -

92. Company Name : **CHL Heattreatment Co., Ltd.**

Address : 24/83-84 Moo 6 Bangna-Trad Km.24, Bangsaothong, King
Aumphur Bangsaothong, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-740-0366-7
Fax. : 662-740-0364
Website : -

93. Company Name : **Pullthana Part and Mold Co., Ltd.**

Address : 85/4 Moo 7 Soi Wadsriwarinnoi, Bangna-Trad Km.18 Rd.,
Bangchalong, Bangplee, Samutprakarn Samutprakarn 10540,
Thailand
Tel. : 662-312-6131
Fax. : 662-312-6518
Website : -

94. Company Name : **Tac Siam Corp Ltd.**

Address : 170/1 Moo 17 Bangphlee Industrial Estate, Soi 4, Teparuk Rd.,
Bangsaotong, King Amphur Bangsaotong,
Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-315-2202-3
Fax. : 662-315-1022
Website : -

95. Company Name : **K.D.K. Die And Parts Co., Ltd.**

Address : 630 Moo 1 Soi Sapbunchai, Phreakasa Rd., Thaiban-Mai, Muang,
Samutprakarn Samutprakarn 10280, Thailand
Tel. : 662-701-4497, 0-2701-4629
Fax. : 662-701-4140
Website : -

96. Company Name : **Charoenphol II Engineering Co., Ltd.**

Address : 219 Moo 3 Theparak Rd., Theparak, Muang,
Samutprakarn Samutprakarn 10270, Thailand
Tel. : 662-753-2280, 662-394-4948
Fax. : 662-753-2281
Website : -

97. Company Name :**Sang Rung Ruang Engineering Co., Ltd.**

Address : 1633 Moo 4 Soi Narai 1, Taparuk Rd., Taparuk, Muang,
Samuthprakarn Samutprakarn 10270, Thailand

Tel. : 662-758-0461, 662-394-6651

Fax. : 662-384-2092

Website :

98. Company Name :**CNS Parts Manufacturing Co., Ltd.**

Address : 13/7 Moo 11, Poochaosamingpri Rd., Bangyaprage, Phrapradaeng,
Samutprakarn Samutprakarn 10130, Thailand

Tel. : 662-380-6445-9, 662-754-4012-3

Fax. : 662-384-1700

Website : -

99. Company Name :**GRP. Hightech Ltd., Part**

Address : 920 Moo 15 Theparak Industrial Estate, Theparak Rd.,
Bangsaothong, King Aumphur Bangsaothong,
Samutprakarn Samutprakarn 10540, Thailand

Tel. : 662-706-0312-5

Fax. : 662-313-1816

Website : -

100. Company Name :**Somboon Advance Technology Co., Ltd.**

Address : 112 Moo 12 Bangna-Trad KM.15 Rd., Bangchalong, Bangplee,
Samutprakarn Samutprakarn 10540, Thailand

Tel. : 662-750-8570-80

Fax. : 662-312-5076

Website : www.somboongroup.com

3 Auto Assemblers

1. Company Name : **Isuzu Motors (Thailand) Co., Ltd.**

Address : 38 Moo 9 PoochaoSamingprai Rd., SamrongTai, Phrapradaeng,
Samutprakarn Samutprakarn 10130, Thailand

Tel. : 662-394-2541

Fax. : 662-394-3522

Website : -

Brand : Isuzu

Vehicle Type : Pick-Up, Truck, Bus

2. Company Name : **Siam Nissan Automobile Co., Ltd.**

Address : 74 Moo 2 Km.21 Bangna-Trad Rd., Srisajarakayai, Sub District
Bangsaothong, Samutprakarn Samutprakarn 10540, Thailand

Tel. : 662-312-8443-55

Fax. : 662-312-8458

Website : -

Brand : Nissan, Suzuki

Vehicle Type : Passenger Car, Pick-Up, Truck

3. Company Name : **Toyota Motor Thailand Co., Ltd.**

Address : 186/1 Moo 1, Old Railway Rd., Samrong Tai, Phrapradaeng,
Samutprakarn Samutprakarn 10130, Thailand

Tel. : 662-386-1000

Fax. : 662-384-7350

Website : www.toyota.co.th

Brand : Toyota

Vehicle Type : Passenger Car, Pick-Up

APPENDIX B

Thai Universities with Mechanical and/or Automotive Engineering Discipline

**The total Thai universities that have machinery engineering discipline and
automotive engineering discipline**

Public University (26)

- 1 Chulalongkorn University
- 2 Kasetsart University
- 3 Thammasat University
- 4 Srinakharinwirot University
- 5 King Mongkut's Institute of Technology North Bangkok
- 6 King Mongkut's Institute of Technology Chaokuntaharn Ladkrabang
- 7 Mahidol University
- 8 Silpakoen University
- 9 Burapha University
- 10 Naresuan University
- 11 Chiang Mai University
- 12 Khon Kaen University
- 13 Ubon Ratchathani University
- 14 Mahasarakham University
- 15 Prince of Songkls University
- 16 Rajamangla University of Technology Thunyaburi
- 17 Rajamangla University of Technology Krungthep
- 18 Rajamangla University of Technology Phranakon
- 19 Rajamangla University of Technology Srivijaya
- 20 Rajamangla University of Technology Lanna
- 21 Rajamangla University of Technology Suvanabhumi
- 22 Rajamangla University of Technology Isan
- 23 Pathumwan Institute of Technology
- 24 Suranaree University of Technology
- 25 Walailak University
- 26 King Mongkut's University of Technology Thonburi

Private University (14)

- 1 Kasem Bundit University
- 2 Saint John's University
- 3 Mahanakorn University of Technology
- 4 Sripatum University
- 5 South-East Asia University
- 6 Saim University
- 7 Eastern Asia University
- 8 Pathumthani University
- 9 Rangsit University
- 10 North-Chiang Mai University
- 11 North-Eastern University
- 12 Asian University of Science and Technology
- 13 Rajapark College
- 14 Thonburi College of Techonology

APPENDIX C

Development of Questionnaire

Operational Definition	Item of Question
<p>1. Firm's Competitiveness is the ability to provide products and services more effectively and efficiently than relevant competitors. This includes sustained success in international markets without protection or subsidises. Firm's competitiveness is based on four development:</p> <ul style="list-style-type: none"> ▪ Technology development; ▪ Product development; ▪ Marketing development; ▪ Human resource development. <p>These development can be improved by firm's expertise and knowledge, cooperate with other firms with expertise, cooperate with universities for expertise, cooperate with other organization, purchase technology from other firms or universities, and obtain consultancy from universities or expert organization.</p> <p>For human resource development, firms can be improved by providing regular training, exchanging expert with universities, and planning to enhance career path/career development for employees.</p>	<ul style="list-style-type: none"> - To strengthen and enhance firm's competitiveness: <ul style="list-style-type: none"> ▪ Technology development; ▪ Product development; ▪ Marketing development; ▪ Human resource development. - To develop firm's technology and business solution: <ul style="list-style-type: none"> ▪ Systematically manage firm's expertise and knowledge; ▪ Cooperate with other firms with expertise in cluster; ▪ Cooperate with university for expertise; ▪ Cooperate with other organizations; ▪ Purchase technology from other firms; ▪ Purchase technology from university. - To improve firm's products: <ul style="list-style-type: none"> ▪ Systematically manage firm's expertise and knowledge; ▪ Cooperate with other firms with expertise in cluster; ▪ Cooperate with university for expertise; ▪ Cooperate with other organizations; ▪ Purchase technology from other firms; ▪ Purchase technology from university. - To improve firm's marketing: <ul style="list-style-type: none"> ▪ Systematically manage firm's expertise and knowledge; ▪ Cooperate with marketing expert from other organizations; ▪ Cooperate with university for expertise; ▪ Obtain consultancy from university.

Operational Definition	Item of Question
	<ul style="list-style-type: none"> - To develop firm's human resource: <ul style="list-style-type: none"> ▪ Recruit undergraduate with skills into workforce; ▪ Plan to enhance career path/career development for employee; ▪ Provide regular training; ▪ Exchange expert with university
<p>2. Relationship is a specific connection and collaboration between related sectors which is designed by various components, i.e., control mutuality, trust, satisfaction, commitment, exchange relationship, and communal relationship:</p> <ul style="list-style-type: none"> ▪ Control mutuality means the degree to which parties agree on who has the rightful power to influence each other; ▪ Trust means one party's level of confidence in and willingness to open itself to the other party; ▪ Satisfaction means the extent to which each party feels favorably toward the other because positive expectations about the relationship are reinforced; ▪ Commitment means the extent to which each party believes that the maintenance and promotion of the relationship is worth expending energy on; ▪ Exchange relationship means in an exchange relationship, one party gives benefits to the other only because the other has provided benefits in the past or is expected to do so in the future; ▪ Communal relationship means in a communal relationship, each party provides benefits to the other because they are concerned for the welfare of the other—even when they get nothing in return. 	<ul style="list-style-type: none"> - Areas that firm might want to collaborate with university: <ul style="list-style-type: none"> ▪ Technology and process development; ▪ Product development; ▪ Marketing development; ▪ Human resource development; ▪ Graduate recruitment; ▪ Business consultancy; ▪ Internship. - Cooperation with university is whether relevant to your interest: <ul style="list-style-type: none"> ▪ Yes; ▪ No. - The reasons why cooperation with university is not relevant to firm's interest: <ul style="list-style-type: none"> ▪ No need; ▪ No respect for university's competence; ▪ No contact; ▪ University's attitude/policy. - Benefits which firm gets from Universities: <ul style="list-style-type: none"> ▪ Personal contact with academic staff; ▪ Access to publication and Literatures; ▪ Access to equipment; ▪ Access to facility; ▪ Attend seminar /conference; ▪ Access to research; ▪ Consulting engineering; ▪ Access to training course; ▪ Purchase the technology spin-Offs; ▪ Purchase the research spin-offs; ▪ Research contact;

Operational Definition	Item of Question
	<ul style="list-style-type: none"> ▪ Consultancy; ▪ Product/instrument testing contact; ▪ Incubation service contact; ▪ Internship science and technology undergraduates; ▪ Graduate and post graduate's research development; ▪ Financing scholarship for research innovation; ▪ Financing scholarship for science and technology undergraduates; ▪ Financing scholarship for graduates and post graduates; ▪ Employee attend training course; ▪ Employee attend to new technology training course; ▪ Recruit more experienced scientist and engineering; ▪ Technology transfer; ▪ Access to commercial development and competitive research; ▪ Career services and placement. <p>- Research spin-offs/invention spin-offs that firm get from university:</p> <ul style="list-style-type: none"> ▪ Research spin-offs; ▪ Invention spin-offs. <p>- Supportive expert you obtain from University:</p> <ul style="list-style-type: none"> ▪ Science and technology expert consultancy; ▪ Exchange science and technology expert; ▪ Exchange engineering expert; ▪ Consultancy engineering; ▪ Employee training; ▪ Student's involvement in project and program. <p>- Firm's expectation from the cooperation.</p>

Operational Definition	Item of Question
<p>3. U-I-G Relationship means a specific connection and collaboration between universities - automotive industry-government (including other related organizations) linkages which have both formal and informal patterns. Direct linkage is through automotive industry-universities, indirect linkages are through universities-government-automotive industry or universities-government-other related organizations-automotive industry. Such relationship benefits the creation of new knowledge, innovation development and social capital for quality of graduates and competitiveness of industry.</p>	<ul style="list-style-type: none"> - Firm's informal cooperation (personal cooperation) with university and other organizations: <ul style="list-style-type: none"> ▪ Personal contact with academic staff; ▪ Access to publication and literatures; ▪ Access to equipment; ▪ Access to facility; ▪ Attend seminar /conference; ▪ Access to research; ▪ Consulting engineering; ▪ Access to training course; ▪ Purchase the technology spin-offs; ▪ Purchase the research spin-offs. - Firm's formal cooperation (by contractible signing) with university and other organizations: <ul style="list-style-type: none"> ▪ Research contract; ▪ Consultancy; ▪ Product/instrument testing contract; ▪ Incubation service contract; ▪ Internship science and technology undergraduates; ▪ Graduate and post graduate's research development; ▪ Financing scholarship for research innovation; ▪ Financing scholarship for science and technology undergraduates; ▪ Financing scholarship for graduates and post graduates.
<p>4. Pattern of U-I-G relationship divides into two patterns, i.e., formal and informal.</p> <p>Formal pattern means U-I-G has collaboration (cooperation) by contractible signing on such activities:</p> <ul style="list-style-type: none"> ▪ Research contract; ▪ Consultancy; ▪ Product/instrument testing contract; 	

Operational Definition	Item of Question
<ul style="list-style-type: none"> ▪ Incubation service contract; ▪ Internship science and technology undergraduates; ▪ Graduates and post graduates' research development; ▪ Financing scholarship for research innovation; ▪ Financing scholarship for science and technology undergraduates; ▪ Financing scholarship for graduates and post graduates; <p>Informal pattern means U-I-G has collaboration (cooperation) by personal contact as follows:</p> <ul style="list-style-type: none"> ▪ Personal contact with academic staff; ▪ Access to publication and literatures; ▪ Access to equipment; ▪ Access to facility; ▪ Attend seminar /conference; ▪ Access to research; ▪ Consulting engineering; ▪ Access to training course; ▪ Purchase the technology spin-offs; ▪ Purchase the research spin-offs. 	
<p>5. University and firm collaboration can be characterized:</p> <ul style="list-style-type: none"> ▪ The engagement of university and firm (firm engaged in collaborate with university and university more engage in the upgrading of their business environment); ▪ The mission and goal statement of university and industry; ▪ The functions of university and firm; ▪ The key roles for university to generate knowledge and transfer knowledge, workforce development, and facilitation of competitiveness initiatives; <ul style="list-style-type: none"> ▪ Higher degree of attraction for staff and students; 	<ul style="list-style-type: none"> - Frequency that firm collaborates with university/other organizations in technology development, product development, marketing development, human resource development, and personnel training and knowledge workers' recruitment: <ul style="list-style-type: none"> ▪ Most relevant; ▪ Moderate; ▪ Little; ▪ Least. - Universities' name which firm collaborates with. - Improving firm' s human resource development through university and other organizations:

Operational Definition	Item of Question
<ul style="list-style-type: none"> Higher impact of research and education. 	<ul style="list-style-type: none"> Cooperate with university for human resource development course; Organizational consultancy; Send employee to attend training course at university; Expert exchange; Employee attends new technology training course; Recruit more experienced scientist and engineering.
<p>6. Firm's factors influence the relationship means the factors that firm selects university for collaboration such as:</p> <ul style="list-style-type: none"> The reputation and prestige anchoring high: technology industry; The high quality in automotive engineering and management; Proximity between cluster/firm and university; Quality of graduate training and skills; Quality and number of graduates, post graduates, and doctorates in engineering; Innovative researches; Intellectual property; Commercial development capacity and competitiveness; Opportunity and capacity for technology transfers. 	<ul style="list-style-type: none"> Criteria that firm selects to collaborate with university: <ul style="list-style-type: none"> The reputation and prestige anchoring high: technology industry; The high quality in automotive engineering and management; Proximity between cluster/firm and university; Quality of graduate training and skills; Quality and number of graduates, post graduates, and doctorates in engineering; Innovative researches; Intellectual property; Commercial development capacity and competitiveness Opportunity and capacity for technology transfers.
<p>7. Government supporting means government acts as an active player to support the cooperation (collaboration) between universities, automotive industry, and related revolving organizations/institutes such as:</p> <ul style="list-style-type: none"> Clearly national direction and policy to support the cooperation; University's function supports the firm/cluster increasingly; University's graduate 	<ul style="list-style-type: none"> View of firm to government, a player in bridging university and industry: <ul style="list-style-type: none"> Very active; Active; Inactive. Impact from acting as a highly active player of government: <ul style="list-style-type: none"> Clearly national direction and policy to support the cooperation; University's function supports the firm/cluster increasingly;

Operational Definition	Item of Question
<p>increasingly relevant to automotive industry needed;</p> <ul style="list-style-type: none"> ▪ University's research/innovation spin-offs for industry needed; ▪ Enhancing university's role on transfer technology; ▪ Enhancing university's role on science and technology; ▪ Available for cooperating between university and firm/cluster; ▪ Financial support from firm/cluster for developing technology; ▪ Getting newly technology transfer beneficiary; ▪ Firm/cluster access to instrument and facilitating service availability; ▪ Increasingly exchanging knowledge, technology and experts. 	<ul style="list-style-type: none"> ▪ University's graduate increasingly relevant to automotive industry needed; ▪ University's research/innovation spin-offs for industry needed; ▪ Enhancing university's role on transfer technology; ▪ Enhancing university's role on science and technology; ▪ Available for cooperating between university and firm/cluster; ▪ Financial support from firm/cluster for developing technology; ▪ Getting newly technology transfer beneficiary; ▪ Firm/cluster access to instrument and facilitating service availability; ▪ Increasingly exchanging knowledge, technology and experts. <p>- Impact from acting as an active player of government:</p> <ul style="list-style-type: none"> ▪ Clearly national direction and policy to support the cooperation; ▪ University's function supports the firm/cluster increasingly; ▪ University's graduate increasingly relevant to automotive industry needed; ▪ University's research/innovation spin-offs for industry needed; ▪ Enhancing university's role on transfer technology; ▪ Enhancing university's role on science and technology; ▪ Available for cooperating between university and firm/cluster; ▪ Financial support from firm/cluster for developing technology ▪ Getting newly technology transfer beneficiary; ▪ Firm/cluster access to instrument and facilitating service

Operational Definition	Item of Question
	<p>availability;</p> <ul style="list-style-type: none"> ▪ Increasingly exchanging knowledge, technology and experts. <p>- Impact from acting as an inactive player of government:</p> <ul style="list-style-type: none"> ▪ National direction and policy to support the cooperation are unclear; ▪ Having a big impact in university's graduate policy and firm/cluster needed; ▪ University's function decreasingly focus on firm/cluster's support; ▪ No cooperation in highly research and innovation; ▪ No financial support from industry for university's graduate; ▪ Lack of expert exchange between university and firm/cluster; ▪ Lack of internship program between university and firm/cluster; ▪ Lack of cooperation between university and Small and Medium Enterprises (SMEs) in equipment and product/instrument testing service; ▪ No impact
<p>8. Appropriate cooperation model means the applicable model to improve the linkages in order to enhance industrial competitiveness and sustainability. The university's role and firm/cluster's role can be cooperated in various actions:</p> <ul style="list-style-type: none"> ▪ Firm should directly contact with university by studying or research for technological problem solving; ▪ Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association should act as cooperative player by collecting general problems from firms to university for finding problem solving; 	<p>- Methods that firm uses to build the cooperation with university in the future, if firm has never linked with any universities:</p> <ul style="list-style-type: none"> ▪ Personal contact with academic staff; ▪ Access to training course; ▪ Internship of science and technology undergraduates; ▪ Research cooperation for new innovation; ▪ Expert exchange; ▪ Financing support for research innovation. <p>- Ways that university's role could support automotive industry's competitiveness in sustainability:</p>

Operational Definition	Item of Question
<ul style="list-style-type: none"> ▪ Firm should cooperate with university by research/innovative financing support and develop new technology; ▪ Expert exchange program between firm and university; ▪ Firm and university should cooperate by producing Cooperative education for support undergraduate internship. 	<ul style="list-style-type: none"> ▪ Engineering consultancy; ▪ Support for human resource development course; ▪ Transfer technology; ▪ Increasingly producing graduates relevant to automotive industry's need; ▪ Incubation service contact; ▪ Producing research spin-off; ▪ Producing technology spin-off; ▪ University-firm cooperation for technological problem solving. - Appropriate cooperation model between university and firm (University's role & firm/cluster's role): <ul style="list-style-type: none"> ▪ Firm should directly contact with university by studying or research for technological problem solving; ▪ Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association should act as cooperative player by collecting general problems from firms to university for finding problem solving; ▪ Firm should cooperate with university by research/innovative financing support and develop new technology; ▪ Expert exchange program between firm and university; ▪ Firm and university should cooperate by producing Cooperative education for support undergraduate internship.

APPENDIX D
Questionnaire for Automotive Company



Siam University
Questionnaires for Automotive-Part Company

December 15, 2006

Dear Company's Owner / Manager/Executive,

I am conducting the research study named "Study of the Relationship between University and Industry in Knowledge Economy. Case Study: Thailand's Automotive Cluster". This survey is part of the project and doctoral dissertation which aims at investigating the linkages and relationship between university and automotive industry and finding applicable models and ways to improve the linkages in order to enhance industrial competitiveness in Thailand.

This survey would provide how university could improve to better serve Thailand's Automotive Cluster in enhancing competitiveness and sustainability.

The information that you share will be kept confidential and will be used only for the purpose of this study.

Thank you.
Jomphong Mongkhonvanit
Assistant President

Questionnaires for Automotive Part Firm

Part 1: Automotive part firm's linkage with university and other organizations

1. What does your firm determine to strengthen and enhance firm's competitiveness?
(you can choose more than 1 item)
 - 1.1 ☐ Technology development
 - 1.2 ☐ Product development
 - 1.3 ☐ Marketing development
 - 1.4 ☐ Human resource development
 - 1.5 ☐ Others (please specify)
2. How does your firm develop its technology and business solution?
(you can choose more than 1 item)
 - 2.1 ☐ Systematically manage firm's expertise and knowledge
 - 2.2 ☐ Cooperate with other firms with expertise in cluster
 - 2.3 ☐ Cooperate with university for expertise
(please specify the university's name)
 - 2.4 ☐ Cooperate with other organizations
 - 2.5 ☐ Purchase technology from other firms
 - 2.6 ☐ Purchase technology from university
(please specify the university's name)
 - 2.7 ☐ Others (please specify)
3. How does your firm improve its productivity? (you can choose more than 1 item)
 - 3.1 ☐ Systematically manage firm's expertise and knowledge
 - 3.2 ☐ Cooperate with other firms with expertise in cluster
 - 3.3 ☐ Cooperate with university for expertise
(please specify the university's name)
 - 3.4 ☐ Cooperate with other organizations
 - 3.5 ☐ Purchase technology from other firms
 - 3.6 ☐ Purchase technology from university
(please specify the university's name)
 - 3.7 ☐ Others (please specify)
4. How does your firm improve its marketing? (you can choose more than 1 item)
 - 4.1 ☐ Systematically manage firm's expertise and knowledge
 - 4.2 ☐ Cooperate with marketing expert from other organizations
 - 4.3 ☐ Cooperate with university for expertise
(please specify the university's name)
 - 4.4 ☐ Obtain consultancy from university
(please specify the university's name)
 - 4.5 ☐ Others (please specify)

5. How does your firm develop its human resource?

(you can choose more than 1 item)

- 5.1 ☐ Recruit undergraduate with skills into workforce
- 5.2 ☐ Plan to enhance career path/career development for employee
- 5.3 ☐ Provide regular training
- 5.4 ☐ Exchange expert with university
- 5.5 ☐ Others (please specify)

6. How far does your firm collaborate with university/other organizations in the following area? (most relevant=1, moderate=2, little=3, and least =4)

- | | 1 | 2 | 3 | 4 |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| 6.1 Technology development
<input type="checkbox"/> | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 6.2 Product development
<input type="checkbox"/> | <input type="checkbox"/> | | <input type="checkbox"/> | <input type="checkbox"/> |
| 6.3 Marketing development
<input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | | <input type="checkbox"/> |
| 6.4 Human resource development
<input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | | <input type="checkbox"/> |
| 6.5 Personnel training
<input type="checkbox"/> | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| and knowledge workers' recruitment | | | | |
| 6.6 Others (please specify) | | | | |

7. Which are the universities that your firm collaborates with?

- 7.1.
- 7.2.
- 7.3.
- 7.4.
- 7.5.

8. According to your cooperation with university, which are the criteria that your firm selects university for collaboration?

(You can choose more than 1 item, please rank from most to least; most relevant=1, 2,3,4,... respectively)

- 8.1 ☐ The reputation and prestige anchoring high technology industry
- 8.2 ☐ The high quality in automotive engineering and management
- 8.3 ☐ Proximity between cluster/firm and university
- 8.4 ☐ Quality of graduate training and skills
- 8.5 ☐ Quality and number of graduates, post graduates, and doctorates in engineering
- 8.6 ☐ Innovative researches
- 8.7 ☐ Intellectual property

- 8.8 ☐ Commercial development capacity and competitiveness
 8.9 ☐ Opportunity and capacity for technology transfers
 8.10 ☐ Others (please specify)

9. How does your firm have **informal cooperation** (personal cooperation) with university and other organizations?
 (You can choose more than 1 item, please rank from most to least; 1=most relevant, 2,3,4,... respectively)

Informal cooperation	University	Other Organizations
9.1 Personal contact with academic staff	<input type="checkbox"/>	<input type="checkbox"/>
9.2 Access to publication and literatures	<input type="checkbox"/>	<input type="checkbox"/>
9.3 Access to equipment	<input type="checkbox"/>	<input type="checkbox"/>
9.4 Access to facility	<input type="checkbox"/>	<input type="checkbox"/>
9.5 Attend seminar /conference	<input type="checkbox"/>	<input type="checkbox"/>
9.6 Access to research	<input type="checkbox"/>	<input type="checkbox"/>
9.7 Consulting engineering	<input type="checkbox"/>	<input type="checkbox"/>
9.8 Access to training course	<input type="checkbox"/>	<input type="checkbox"/>
9.9 Purchase the technology spin-offs	<input type="checkbox"/>	<input type="checkbox"/>
9.10 Purchase the research spin-offs	<input type="checkbox"/>	<input type="checkbox"/>
9.11 Others (please specify)	<input type="checkbox"/>	<input type="checkbox"/>
.....		
9.12 None	<input type="checkbox"/>	<input type="checkbox"/>

10. How does your firm have **formal cooperation** (by contractible signing) with university and other organizations?
 (You can choose more than 1 item, please rank from most to least; 1=most relevant, 2,3,4,... respectively)

Formal cooperation	University	Other Organizations
10.1 Research contract	<input type="checkbox"/>	<input type="checkbox"/>
10.2 Consultancy	<input type="checkbox"/>	<input type="checkbox"/>
10.3 Product/instrument testing contract	<input type="checkbox"/>	<input type="checkbox"/>
10.4 Incubation service contract	<input type="checkbox"/>	<input type="checkbox"/>
10.5 Internship science and technology undergraduates	<input type="checkbox"/>	<input type="checkbox"/>
10.6 Graduate and post graduate's research development	<input type="checkbox"/>	<input type="checkbox"/>
10.7 Financing scholarship for research innovation	<input type="checkbox"/>	<input type="checkbox"/>
10.8 Financing scholarship for science and technology undergraduates	<input type="checkbox"/>	<input type="checkbox"/>
10.9 Financing scholarship for graduates and post graduates	<input type="checkbox"/>	<input type="checkbox"/>
10.10 Others (please specify)	<input type="checkbox"/>	<input type="checkbox"/>
.....		

10.11 None	<input type="checkbox"/>	<input type="checkbox"/>
------------	--------------------------	--------------------------

11. How does your firm improve its **human resource development** through university and other organizations?
(You can choose more than 1 item, please rank from most to least; 1 = most relevant, 2,3,4,... respectively)

Human resource development	University	Other Organizations
11.1 Cooperate with university for human resource development course	<input type="checkbox"/>	<input type="checkbox"/>
11.2 Organizational consultancy	<input type="checkbox"/>	<input type="checkbox"/>
11.3 Send employee to attend training course at university	<input type="checkbox"/>	<input type="checkbox"/>
11.4 Expert exchange	<input type="checkbox"/>	<input type="checkbox"/>
11.5 Employee attends new technology training course	<input type="checkbox"/>	<input type="checkbox"/>
11.6 Recruit more experienced scientist and engineering	<input type="checkbox"/>	<input type="checkbox"/>
11.7 Others (please specify)	<input type="checkbox"/>	<input type="checkbox"/>

12. How do you view government as a player in bridging university and industry?

- 12.1 ☐ Very active (answer in question No.13)
12.2 ☐ Active (shift to answer in question No.14)
12.3 ☐ Inactive (shift to answer in question No.15)

13. **Only answer this question if you ticked No.12.1.**

In your opinion, what is the impact from **acting as a highly active player** of government? (You can choose more than 1 item)

- 13.1 ☐ Clearly national direction and policy to support the cooperation
13.2 ☐ University's function supports the firm/cluster increasingly
13.3 ☐ University's graduate increasingly relevant to automotive industry needed
13.4 ☐ University's research/innovation spin-offs for industry needed
13.5 ☐ Enhancing university's role on transfer technology
13.6 ☐ Enhancing university's role on science and technology
13.7 ☐ Available for cooperating between university and firm/cluster
13.8 ☐ Financial support from firm/cluster for developing technology
13.9 ☐ Getting newly technology transfer beneficiary
13.10 ☐ Firm/cluster access to instrument and facilitating service availability
13.11 ☐ Increasingly exchanging knowledge, technology and experts

13.12 ☐ Others (please specify)

14. **Only answer this question if you ticked No.12.2.**

What is the impact from **acting as an active player** of government?

(You can choose more than 1 item)

- 14.1 ☐ Clearly national direction and policy to support the cooperation
- 14.2 ☐ University's function supports the firm/cluster increasingly
- 14.3 ☐ University's graduate increasingly relevant to automotive industry needed
- 14.4 ☐ University's research/innovation spin-offs for industry needed
- 14.5 ☐ Enhancing university's role on transfer technology
- 14.6 ☐ Enhancing university's role on science and technology
- 14.7 ☐ Available for cooperating between university and firm/cluster
- 14.8 ☐ Financial support from firm/cluster for developing technology
- 14.9 ☐ Getting newly technology transfer beneficiary
- 14.10 ☐ Firm/cluster access to instrument and facilitating service availability
- 14.11 ☐ Increasingly exchanging knowledge, technology and experts
- 14.12 ☐ Others (please specify)

15. **Only answer this question if you ticked No.12.3.**

What is the impact from **acting as an inactive player** of government?

(You can choose more than 1 item)

- 15.1 ☐ National direction and policy to support the cooperation are unclear.
- 15.2 ☐ Having a big impact in university's graduate policy and firm/cluster needed
- 15.3 ☐ University's function decreasingly focus on firm/cluster's support
- 15.4 ☐ No cooperation in highly research and innovation
- 15.5 ☐ No financial support from industry for university's graduate
- 15.6 ☐ Lack of expert exchange between university and firm/cluster
- 15.7 ☐ Lack of internship program between university and firm/cluster
- 15.8 ☐ Lack of cooperation between university and Small and Medium Enterprises (SMEs) in equipment and product/instrument testing service
- 15.9 ☐ No impact
- 15.10 ☐ Others (please specify)

16. As you wish, what are the areas that you might want to collaborate with university?

(You can choose more than 1 item, please rank from most to least; 1=most relevant, 2,3,4,... respectively)

- 16.1 ☐ Technology and process development
- 16.2 ☐ Product development
- 16.3 ☐ Marketing development
- 16.4 ☐ Human resource development
- 16.5 ☐ Graduate recruitment
- 16.6 ☐ Business consultancy
- 16.7 ☐ Internship
- 16.8 ☐ Others (please specify)

17. Do you feel that cooperation with university is relevant to your interest?

17.1 ☐ Yes

17.2 ☐ No

If the **answer is no**, why? (You can choose more than 1 item, please rank from most to least; 1=most relevant, 2,3,4,... respectively)

- 17.2.1 ☐ No need
- 17.2.2 ☐ No respect for university's competence
- 17.2.3 ☐ No contact
- 17.2.4 ☐ University's attitude/policy
- 17.2.5 ☐ Other (please specify).....

Part 2: Benefit from university

18. What does your firm **get benefits** from universities?

(You can choose more than 1 item)

- 18.1 ☐ Personal contact with academic staff
- 18.2 ☐ Access to publication and literatures
- 18.3 ☐ Access to equipment
- 18.4 ☐ Access to facility
- 18.5 ☐ Attend seminar /conference
- 18.6 ☐ Access to research
- 18.7 ☐ Consulting engineering
- 18.8 ☐ Access to training course
- 18.9 ☐ Purchase the technology spin-offs
- 18.10 ☐ Purchase the research spin-offs
- 18.11 ☐ Research contact
- 18.12 ☐ Consultancy
- 18.13 ☐ Product/instrument testing contact
- 18.14 ☐ Incubation service contact
- 18.15 ☐ Internship science and technology undergraduates
- 18.16 ☐ Graduate and post graduate's research development
- 18.17 ☐ Financing scholarship for research innovation
- 18.18 ☐ Financing scholarship for science and technology undergraduates
- 18.19 ☐ Financing scholarship for graduates and post graduates
- 18.20 ☐ Employee attend training course
- 18.21 ☐ Employee attend to new technology training course
- 18.22 ☐ Recruit more experienced scientist and engineering
- 18.23 ☐ Technology transfer
- 18.24 ☐ Access to commercial development and competitive research
- 18.25 ☐ Career services and placement
- 18.26 ☐ None
- 18.27 ☐ Others (please specify)
-
-

19. Please specify the **research spin-offs/invention spin-offs** that you get from university?

19.1 ☐ **Research spin-offs**

19.2 ☐ **Invention spin-offs**

- 1.
- 2.
- 3.
- 4.
- 5.

- 1.
- 2.
- 3.
- 4.
- 5.

Part 3: Expectation of support from university and how to make the relationship more meaningful;

20. Please specify the **supportive expert** you obtain from university?

(You can choose more than 1 item)

- 20.1 ☐ Science and technology expert consultancy
- 20.2 ☐ Exchange science and technology expert
- 20.3 ☐ Exchange engineering expert
- 20.4 ☐ Consultancy engineering
- 20.5 ☐ Employee training
- 20.6 ☐ Student's involvement in project and program
- 20.7 ☐ Others (please specify)

21. What is your **firm's expectation from the cooperation?**

- 21.1.....
- 21.2.
- 21.3.....
- 21.4.....
- 21.5.....

22. As your firm has **never linked** with any universities, how do you **build the cooperation** with university in the future?
(You can choose more than 1 item, and **if your firm has linked with any university, please shift to answer question No.23**)

- 22.1 ☐ Personal contact with academic staff
- 22.2 ☐ Access to training course
- 22.3 ☐ Internship of science and technology undergraduates
- 22.4 ☐ Research cooperation for new innovation
- 22.5 ☐ Expert exchange
- 22.6 ☐ Financing support for research innovation
- 22.7 ☐ Others (please specify)

23. In your opinion, how does the university's role **support automotive industry's competitiveness** in sustainability? (You can choose more than 1 item)

- 23.1 ☐ Engineering consultancy
- 23.2 ☐ Support for human resource development course
- 23.3 ☐ Transfer technology
- 23.4 ☐ Increasingly producing graduates relevant to automotive industry's need
- 23.5 ☐ Incubation service contact
- 23.6 ☐ Producing research spin-off
- 23.7 ☐ Producing technology spin-off
- 23.8 ☐ University-firm cooperation for technological problem solving
- 23.9 ☐ Others (please specify)

24. In your opinion, what is the **appropriate cooperation model** between university and firm? (University's role & firm/cluster's role)
- 24.1 ☐ Firm should directly contact with university by studying or research for technological problem solving
 - 24.2 ☐ Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association should act as cooperative player by collecting general problems from firms to university for finding problem solving
 - 24.3 ☐ Firm should cooperate with university by research/innovative financing support and develop new technology
 - 24.4 ☐ Expert exchange program between firm and university
 - 24.5 ☐ Firm and university should cooperate by producing Cooperative education for support undergraduate internship
 - 24.6 ☐ Others (please specify)

Part 4: Company profile

25. Company:
- Affiliation with foreign firm:
26. Product & service:
27. Number of full-time employees:
28. Approximate percentage of employees who are engineering degree holder
- Domestic degree holder %
- Foreign degree holder..... %
29. Approximate percentage of foreign engineers:
30. Type of services you operate
- | | |
|--|---|
| <input type="checkbox"/> Basic operation | <input type="checkbox"/> Technical work |
| <input type="checkbox"/> Design | <input type="checkbox"/> Research and Development |
31. Thai employees are expected to work on
- | | |
|--|---|
| <input type="checkbox"/> Basic operation | <input type="checkbox"/> Technical work |
| <input type="checkbox"/> Design | <input type="checkbox"/> Research and Development |

Thank you

Surveyor's record of interview

Name of the respondent:
Name of company:
Address:
.....
E-mail: Tel: Fax:
Date: Time: Place:
Surveyor's name:

Thank you very much for your response. Your responses will be used in a study that is a part of a doctoral dissertation aiming to enhance competitiveness of automotive industry in Thailand. In case that we need a further interview, will you be happy to give a further interview?

☐ Yes ☐ No

Interview Guide for Universities, Research Institutes and Revolving Organizations

Interview Guide for Universities

University profile: (name, location, organization, policy and mission, function, etc.)

University's direct role

- 1) How does the university directly involve in the automotive cluster?
- 2) How does the university promote the technology transfer?
- 3) How does the university directly involve in the commercial actions to support the entrepreneurial culture of cluster?
- 4) What are the special features of university highly regarded by the automotive cluster/firm?

Technology transfer process

- 1) What is the scientific position of the university's research?
- 2) How does the university's research cooperate with the automotive firms?
- 3) What are the university's research spin-offs?
- 4) How does the university develop entrepreneurial culture to support cluster or firms?
- 5) Does the university have any programs to support the graduates establishing new companies?
- 6) What kind of processes does the university use to connect between Thai automotive cluster/firms and the graduates?
- 7) Where are the university's research financing allocated from?
- 8) Does the university establish the science park for strengthening the interaction between the university and industry?
- 9) Does the university develop any internship programs with the industry?
- 10) Does the university have skilled-training joint with the industry?
- 11) Does the university have consultancy with the industry? If yes, how?
- 12) Does the university have incubation services to support the industry?

The support from industry needed/Government policy/ cooperation model between university and firm

- 1) What kind of supports you need from the industry?
- 2) How to make your relationship with the industry/firms in the automotive cluster more fruitful?
- 3) Does the government determine the **direction and policy** on relationship between university and firm/cluster? **If yes, how is the policy? If not, what is the impact on the cooperation?**
- 4) How the university should be supported to firm **in order to develop firm's competitiveness** in sustainability?
- 5) What is the **appropriate cooperation model** of university and firm/cluster? (University's role & firm/cluster's role)

.....

Interview Guide for Research Institutes and Revolving Organizations

Research institution or revolving organization profile: (name, location, organization, policy and mission, function, etc.)

Technology transfer process

- 1) What is the position of your institution?
- 2) How does your institution's research and work cooperating with the automotive firms?
- 3) What are your objectives and output?
- 4) How does your institution develop entrepreneurial culture to support cluster or firms?
- 5) Does your institution have any programs to support the graduates of university establishing new companies?
- 6) What kind of processes does your institution use to connect between Thai automotive cluster/firms to the graduates of university?
- 7) Where are your funding allocated from?
- 8) Does your institution establish the science park for strengthening the interaction between the university and industry?
- 9) Does your institution develop any internship programs with the industry?
- 10) Does your institution have skilled-training joint with the industry?
- 11) Does your institution have consultancy with the industry? If yes, how?
- 12) Does your institution have incubation services to support the industry?

Government policy/ cooperation model between university, research institute and firm

- 1) Does the government determine the **direction and policy** on relationship between university and firm/cluster? **If yes, how is the policy? If not, what is the impact on the cooperation?**
- 2) How the research institution could support firms **to develop firm's competitiveness and sustainability?**
- 3) What is the **appropriate cooperation model** among research institution, university and firm? (Research institution's role, University's role & firm/cluster's role)

.....

Interview Guide for Auto Assemblers and Auto Part Firms

Automotive firms profile: (name, product and service, type of firm, location, number of employees, etc.)

Structural question:

- 1) Does your firm have policies on
 - a. Firm's competitiveness
 - b. Creating the linkages with Thai universities and related automotive research institutes
- 2) How does your firm collaborate with Thai universities on technology and innovation transfer?
- 3) How do some agents (Thai universities and research institutes and revolving organizations) support Thai entrepreneurs (auto-part producers) to decrease their dependency from transnational (assemblies)
- 4) How completely JTEPA affect to Thai entrepreneurs?
- 5) How does Thailand become the Asian production base for automotive industry and strengthen their auto-part industry?
- 6) How does the presently Thai universities-automotive industry cooperation? If we desire the more cooperation, what should each sectors (industry, universities, and government) action?
- 7) How do Thai universities, research institutes and revolving organizations push the status of pure Thai auto-part firms to become closer partners with multination corporations more than the present?

APPENDIX E

In-Depth Interview List

1. Universities

1.1 University Name : **Chulalongkorn University**

Interviewee : Head of Mechanical Engineering Department

Address : Phaya Thai Rd., Wang Mai, Pathum Wan, Bangkok 10330, Thailand

Tel. : 662-218-6435

Fax. : 662-252-2889

Website : www.eng.chula.ac.th/~meweb/

1.2 University Name : **King Mongkut's Institute of Technology North Bangkok**

Interviewee : 1. Head of Mechanical and Aerospace Engineering Department

2. Director of Science and Technology Research Center

3. Deputy Director of Automated Manufacturing System, Thai-French Innovation Centre

Address : 1518 Pibulsongkram Rd., Bangsue, Bangkok 10800, Thailand

Tel. : 662-913 -2500, 662-913-2500 ext.1510, 662-585 3810

Fax. : 662-587-4350, 662-556-1306, 662 586 9014

Website : www.me.kmitnb.ac.th, www.research.kmitnb.ac.th, www.tfic.kmitnb.ac.th

1.3 University Name : **King Mongkut's Institute of Technology Ladkrabang**

Interviewee : Head of Mechanical Engineering Department

Address : 3 M.2 Chalongkrung Rd., Ladkrabang Bangkok 10520, Thailand

Tel. : 662-326-4197

Fax. : 662-326-4198

Website : www.kmitl.ac.th/mechanic/index.html

1.4 University Name : **King Mongkut's University of Technology Thonburi**

Interviewee : Vice President

Address : 126 Pracha-Uthit Rd., Bangmod, Tungkru, Bangkok 10140, Thailand

Tel. : 662-470-8013

Fax. : 662-872-9087

Website : www.kmutt.ac.th

1.5 University Name : **Rajamangala University of Technology Thanyaburi**
Interviewee : Head of Mechanical Engineering Department
Address : 39 M.1, Rangsit-Nakhonnayok Rd., Klong Hok, Thanyaburi
Pathum Thani 12110, Thailand
Tel. : 662-549-3435
Fax. : 662-549-3432
Website : www.en.rmut.ac.th/merit

1.6 University Name : **Rajamangala University of Technology Phra Nakhon
North Bangkok Campus**
Interviewee : Head of Mechanical Engineering Department
Address : 1381 Piboonsongkram Rd. Bangsue Bangkok 10800,
Thailand
Tel. : 662-913-2424 ext.138
Fax. : 662-585-9175
Website : www.eng.mut.ac.th/Mechan/index.asp

1.7 University Name : **Mahanakorn University of Technology**
Interviewee : Head of Mechanical Engineering Department
Address : 51 M.1 Chermsumpan Rd., Kratumrai, Nongjok, Bangkok
10530, Thailand
Tel. : 662-988-3666 ext.241
Fax. : 662-988-3687
Website : www.eng.mut.ac.th/Mechan/index.asp

1.8 University Name : **Siam University**
Interviewee : Head of Automotive Engineering Department
Address : 235 Petkasem Rd., Bangkae, Bangkok 10160, Thailand
Tel. : 662-457-0068 ext.157
Fax. : 662-868-6856
Website : <http://ae.siam.edu>

2. Research Institute

- 2.1 Institute Name : **National Metal and Materials Technology Center (MTEC)**
Interviewee : Director
Address : 114 Thailand Science Park Paholyothin Rd., Klong 1,
Klong Luang, Pathumthani 12120, Thailand
Tel. : 662-564-6500
Fax. : 662-564-6501-5
Website : www.mtec.or.th

3. Related and Supporting Organizations

- 3.1 Institute Name : **Thailand Automotive Institute (TAI)**
Interviewee : Director
Address : 655 Soi 1, Bang Poo Industrial Estate, M.2, Sukhumvit Rd.,
Km.34, Muang, Samutprakarn 10280, Thailand
Tel. : 662-324-0710
Fax. : 662-323-9598
Website : www.thaiauto.or.th
-
- 3.2 Institute Name : **Thai Auto-Parts Manufacturers Association (TAPMA)**
Interviewee : Director of Cluster/SME Project
Address : 86/6 ,1st Floor ,Bureau of Supporting Industries
Development (BSID) , Soi Trimit ,Rama 4 Rd., Klongtoey
,Bangkok 10110, Thailand
Tel. : 662-712 2246-7, 662-712 2971, 662-712 3594-6
Fax. : 662-712-2970, 662-712-3597
Website : www.thaiautoparts.or.th
-
- 3.3 Institute Name : **Thailand's Society of Automotive Engineer (TSAE)**
Interviewee : President
Address : Automotive Engineering Building, Chulalongkorn
University, Phayathai Rd., Bangkok 10330, Thailand
Tel. : 662-218-6617
Fax. : 662-218-6636
Website : www.tsae.or.th
-
- 3.4 Institute Name : **Thai Automotive Industry Association (TAIA)**
Interviewee : President
Address : Queen Sirikit National Convention Center, Zone D, 2nd
Floor, Room No.201/20
60 New Rachadapisek Road, Klong Toey, Bangkok 10110,
Thailand
Tel. : 662-229 4310
Fax. : 662-229 4311
Website : www.taia.or.th
-

4. Firms

- **Auto-Part Producer**

- 4.1 Company Name : **Somboon Advance Technology Co., Ltd.**
Interviewee : Executive Advisor
Address : 112 Moo 12 Bangna-Trad KM.15 Rd., Bangchalong,
Bangplee, Samutprakarn Samutprakarn 10540, Thailand
Tel. : 662-750-8570-80
Fax. : 662-312-5076
Website : www.somboongroup.com
-

- **Auto-Assemblers**

- 4.2 Company Name : **Thairung Union Car Public Co., Ltd.**
Interviewee : General Manager
Address : 28/6 Moo 1 Petchkasem Rd. Kwaeng
Nongkangploo Bangkok 10160, Thailand
Tel : 662-431-0071-2, 662-420-0076, 662-431-0065
Fax : 662-420-3486, 662-812-0844
Brand : Isuzu
Vehicle Type : Pick-Up/Modifications
-

- 4.3 Company Name : **Toyota Motor Thailand Co., Ltd.**
Interviewee : Senior Vice President Technical Division
Address : 186/1 Moo 1, Old Railway Rd., Samrong Tai,
Phrapradaeng, Samutprakarn Samutprakarn 10130,
Thailand
Tel. : 662-386-1064
Fax. : 662-386-1887
Website : www.toyota.co.th
Brand : Toyota
Vehicle Type : Passenger Car, Pick-Up
-

APPENDIX F

In-Depth Interview Schedule

Date	Time	Samples	Type of Samples	Position	Note
5-Jan-07	1.30 p.m.	Science and Technology Research Center (King Mongkut's Institute of Technology North Bangkok)	University	Director of Science and Technology Research Center	Tryout
8-Jan-07	2.00 p.m.	Thailand Automotive Institute (TAI)	Research Institute/ Other Organization	Director of Thailand Automotive Institute	Tryout
29-Jan-07	10.00 a.m.	Musashi Auto Parts Co.,Ltd.	Firm (Auto-part Producer)	Personnel & General Affairs Manager	Tryout
29-Jan-07	2.00 p.m.	TR Technical Center Co., Ltd. (Affiliation with Thairadiator Manufacturing Co., Ltd.)	Firm (Auto-part Producer)	1. Mechanical Development Manager 2. Human Resource Manager	Tryout
24-Sep-07	10.00 a.m.	Chulalongkorn University	University	Head of Mechanical Engineering Department	
25-Sep-07	8.00 a.m.	Somboon Group	Firm	Executive Advisor	

Date	Time	Samples	Type of Samples	Position	Note
25-Sep-07	1.00 p.m.	King Mongkut's Institute of Technology North Bangkok	University	Head of Mechanical and Aerospace Engineering Department	
25-Sep-07	3.00 p.m.	Thai-French Innovation Centre (King Mongkut's Institute of Technology North Bangkok)	University	Deputy Director of Automated Manufacturing System	
26-Sep-07	2.00 p.m.	Rajamangala University of Technology Phra Nakhon North Bangkon Campus	University	Head of Mechanical Engineering Department	
27-Sep-07	10.00 a.m.	Mahanakorn University of Technology	University	Head of Mechanical Engineering Department	
27-Sep-07	1.30 p.m.	King Mongkut's Institute of Technology Ladkrabang	University	Head of Mechanical Engineering Department	
1-Oct-07	10.30 a.m.	Rajamangala University of Technology Thanyaburi	University	Head of Mechanical Engineering Department	
1-Oct-07	1.30 p.m.	Thai Auto-Parts Manufacturers Association (TAPMA)	Research Institute/ Other Organization	Director of Cluster/SME Project	
1-Oct-07	9.00 a.m.	Siam University	University	Head of Automotive Engineering Department	
12-Oct-07	1.00 p.m.	National Metal and Materials Technology Center (MTEC)	Research Institute/ Other Organization	Director of MTEC	

Date	Time	Samples	Type of Samples	Position	Note
24-Oct-07	10.00 a.m.	Thairung Union Car Co., Ltd.	Firm	General Manager	
8-Nov-07	9.00 a.m.	Toyota Motor Thailand Co., Ltd.	Firm	Senior Vice President and in behalf of President of Thai Automotive Industry Association (TAIA)	
8-Nov-07	1.00 a.m.	King Mongkut's University of Technology Thonburi	University	Vice President	
22-Nov-07	10.00 a.m.	Society of Automotive Engineer - Thailand (TSAE)	Other Organization	President	

APPENDIX G

Statistic Explaining Figure 19-46 in Chapter 4

Table 19: Fields which firms select to strengthen and enhance their competitiveness
(shown in Figure 19-23 in Chapter 4)

List	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
Fields which firms select to strengthen and enhance their competitiveness			
- Technology and business solution development	100.0	80.0	77.1
- Productivity development	40.0	50.0	91.4
- Human resource development	40.0	80.0	60.0
- Marketing development	100.0	100.0	62.9
- Others	0.0	30.0	0.0
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
1. Technology and business solution development			
- Systematically manage firm's expertise and knowledge	100.0	100.0	74.3
- Cooperate with other firms with expertise in cluster	0.0	20.0	37.1
- Cooperate with university for expertise	0.0	0.0	20.0
- Cooperate with other organizations	100.0	50.0	60.0
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
2. Productivity development			
- Systematically manage firm's expertise and knowledge	100.0	100.0	82.9
- Cooperate with other firms with expertise in cluster	0.0	50.0	51.4
- Cooperate with university for expertise	0.0	0.0	20.0
- Cooperate with other organizations	100.0	50.0	34.3
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
3. Marketing development			
- Systematically manage firm's expertise and knowledge	100.0	100.0	78.6
- Cooperate with marketing expert from other organizations	40.0	50.0	50.0
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

List	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
4. Human resource development			
- Recruit undergraduate with skills into workforce	40.0	40.0	42.9
- Plan to enhance career path/career development for employee	100.0	50.0	51.4
- Provide regular training	100.0	100.0	85.7
Total	100.0	100.0	100.0
(N=50)	(N=5)	(N=10)	(N=35)

Table 20: Cooperation with universities: criteria and university choice (shown in Figure 24-25 in Chapter 4)

List	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
1. Firms' preferred criteria to select a university to collaborate with			
- The reputation and prestige anchoring high technology industry	0.0	100.0	83.3
- The high quality in automotive engineering and management	0.0	20.0	36.7
- Proximity between cluster/firm and university	0.0	20.0	36.7
- Quality of graduate training and skills	0.0	50.0	73.3
- Quality and number of graduates, post graduates, and doctorates in engineering	0.0	30.0	16.7
- Innovative researches	0.0	0.0	56.7
- Intellectual property	0.0	0.0	36.7
- Commercial development capacity and competitiveness	0.0	20.0	43.3
- Opportunity and capacity for technology transfers	100.0	20.0	50.0
Total	100.0	100.0	100.0
(N=50)	(N=5)	(N=10)	(N=35)
2. Universities that firms select to collaborate with			
- King Mongkut's University of Technology Thonburi	0.0	0.0	100.0
- King Mongkut's Institute of Technology North Bangkok	0.0	0.0	37.5
Total	100.0	100.0	100.0
(N=50)	(N=5)	(N=10)	(N=35)

Table 21: Areas and levels that firms collaborates with universities and other organizations (shown in Figure 26-30)

Level of collaboration	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
1. Technology development cooperation			
- Most relevant	0.0	20.0	14.3
- Moderate	40.0	0.0	34.3
- Little	60.0	30.0	22.9
- Least	0.0	50.0	22.9
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
2. Productivity development cooperation			
- Most relevant	40.0	20.0	0.0
- Moderate	60.0	0.0	57.1
- Little	0.0	30.0	8.6
- Least	0.0	50.0	26.8
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
3. Marketing development cooperation			
- Most relevant	100.0	0.0	0.0
- Moderate	0.0	20.0	17.1
- Little	0.0	30.0	54.3
- Least	0.0	50.0	14.3
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
4. Human resource development cooperation			
- Most relevant	40.0	20.0	20.0
- Moderate	0.0	0.0	34.3
- Little	0.0	0.0	14.3
- Least	0.0	80.0	17.1
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
5. Personnel training and Knowledge workers' recruitment cooperation			
- Most relevant	40.0	0.0	20.0
- Moderate	0.0	50.0	34.3
- Little	60.0	30.0	14.3
- Least	0.0	20.0	17.1
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Table 22: Informal and formal cooperation with universities and other organizations (shown in Figure 31-34)

Type of Cooperation	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
1. Informal cooperation			
1.1 With universities			
- Personal contact with academic staff	0.0	62.5	100.0
- Access to publication and literatures	0.0	0.0	38.5
- Access to equipment	0.0	0.0	23.1
- Access to facility	0.0	0.0	23.1
- Attend seminar /conference	0.0	0.0	76.9
- Access to research	0.0	0.0	61.5
- Consulting engineering	0.0	25.0	76.9
- Access to training course	0.0	37.5	76.9
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
1.2 With other organizations			
- Personal contact with academic staff	0.0	62.5	100.0
- Access to publication and literatures	0.0	0.0	38.5
- Access to equipment	0.0	0.0	23.1
- Access to facility	0.0	0.0	23.1
- Attend seminar /conference	0.0	0.0	76.9
- Access to research	0.0	0.0	61.5
- Consulting engineering	0.0	25.0	76.9
- Access to training course	0.0	37.5	76.9
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
2. Formal cooperation			
2.1 With universities			
- Research contact	0.0	0.0	55.6
- Consultancy	100.0	0.0	72.2
- Product/instrument testing contact	0.0	100.0	27.8
- Incubation service contact	0.0	0.0	33.3
- Internship science and technology undergraduates	0.0	100.0	55.6
- Graduate and post graduate's research development	0.0	0.0	44.4
- Financing scholarship for research innovation	0.0	0.0	50.0
- Financing scholarship for science and technology Undergraduates	0.0	0.0	44.4
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Type of Cooperation	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
2.2 With other organizations			
- Research contact	0.0	0.0	37.5
- Consultancy	100.0	100.0	56.3
- Product/instrument testing contact	100.0	40.0	100.0
- Incubation service contact	0.0	0.0	18.8
- Internship science and technology undergraduates	0.0	0.0	37.5
- Graduate and post graduate's research development	0.0	0.0	37.5
- Financing scholarship for research innovation	0.0	0.0	18.8
- Financing scholarship for science and technology undergraduates	0.0	0.0	18.8
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Table 23: Improving firms' human resource development (shown in Figure 35-36)

Human resource development	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
1. Through universities			
- Cooperate with university for human resource development course	0.0	0.0	61.1
- Organizational consultancy	0.0	25.0	44.4
- Send employee to attend training course at university	0.0	37.5	66.7
- Expert exchange	0.0	0.0	16.7
- Employee attends new technology training course	0.0	0.0	72.2
- Recruit more experienced scientist and engineering	100.0	37.5	77.8
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)
2. Through other organizations			
- Cooperate with university for human resource development course	100.0	71.4	43.5
- Organizational consultancy	40.0	100.0	78.3
- Send employee to attend training course at university	0.0	71.4	69.6
- Expert exchange	0.0	0.0	43.5
- Employee attends new technology training course	0.0	0.0	47.8
- Recruit more experienced scientist and engineering	40.0	28.6	43.5
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Table 24: Supportive experts getting from universities (shown in Figure 37)

University's supportive experts' services	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
- Consultancy engineering	0.0	0.0	76.9
- Science and technology expert consultancy	0.0	0.0	46.2
- Exchange science and technology expert	0.0	0.0	23.1
- Exchange engineering expert	0.0	0.0	23.1
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Table 25: Firm's expectations to receive from universities (shown in Figure 38)

Firm's expectations	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
- Human resource development	100.0	100.0	84.6
- Technology/process development	100.0	0.0	53.8
- Marketing development	0.0	0.0	23.1
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

Table 26: Future cooperation with universities (shown in Figure 39-41)

Future cooperation with universities	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
Yes	40.0	100.0	71.4
No	60.0	0.0	28.6
Grand Total (N=50)	100.0 (N=5)	100.0 (N=8)	100.0 (N=35)
- If Yes			
- By personal contact with academic staff	0.0	100.0	16.7
- By access to training course	0.0	100.0	66.7
- Internship of science and technology undergraduates	0.0	57.1	58.3
- By research cooperation for new innovation	0.0	42.9	50.0
- If No			
- Because of no contact	60.0	0.0	20.0
- Because of other reason (firm is in investment period)	0.0	0.0	8.6

Table 27: Responses on the government's role (shown in Figure 42-45)

Responses on government's role	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
- Very active player	0.0	0.0	20.0
- Active player	40.0	80.0	47.0
- Inactive player	60.0	20.0	33.0
Grand total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=30)
- Impacts from government acting as a very active contributor			
- Clearly national direction and policy to support the cooperation	0.0	0.0	66.7
- University's graduate increasingly relevant to automotive industry needed	0.0	0.0	66.7
- University's function supports the firm/cluster increasingly	0.0	0.0	33.3
	100.0 (N=0)	100.0 (N=0)	100.0 (N=6)
- Impacts from government acting as an active player			
- Clearly national direction and policy to support the cooperation	100.0	62.5	78.6
- University's function supports the firm/cluster increasingly	100.0	37.5	64.3
- University's graduate increasingly relevant to automotive industry needed	0.0	62.5	78.6
- University's research/innovation spin-offs for industry needed	100.0	25.0	42.9
- Enhancing university's role on transfer technology	0.0	62.5	21.4
- Enhancing university's role on science and technology	0.0	62.5	42.9
- Available for cooperating between university and firm/cluster	0.0	0.0	64.3
	100.0 (N=2)	100.0 (N=8)	100.0 (N=14)
- Impacts from government acting as an inactive player			
- National direction and policy to support the cooperation inaccuracy	100.0	100.0	100.0
- Having a big impact in university's graduate policy and firm/cluster needed	0.0	0.0	50.0
- University's function decreasingly focus on firm/cluster's support	0.0	0.0	20.0
- No cooperation in highly research and innovation	0.0	100.0	50.0
- No financial support from industry for university's graduate	100.0	100.0	70.0
- Lack of expert exchange between university and firm/cluster	0.0	0.0	30.0
	100.0 (N=3)	100.0 (N=2)	100.0 (N=10)

Table 28: Appropriate model of cooperation between universities and firms
(universities' role & firms/cluster role) (shown in Figure 46)

Appropriate model of cooperation	Percentage		
	Multinational Corporations	Joint Ventures	Pure Thai Companies
- Firm should directly contact with university by studying or research for technological problem solving	100.0	30.0	70.0
- Thailand Automotive Institute or Thai Auto-Parts Manufacturers Association should act as cooperative player by collecting general problems from firms to university for finding problem solving	0.0	70.0	53.3
- Firm should cooperate with university by research/innovative financing support and develop new technology	60.0	0.0	60.0
- Expert exchange program between firm and university	0.0	70.0	60.0
Total (N=50)	100.0 (N=5)	100.0 (N=10)	100.0 (N=35)

APPENDIX H

Thailand's Technological University Model

According to my recent work with the National Council of Education on the Project of Research and Development of Thailand's Technological University Model (Siam University, 2007) to find the model of technological university that serves interest of industry and national competitiveness, the researchers studied five institutions with best practices overseas (Nanyang Technological University-Singapore, Tokyo Institute of Technology-Japan, the University of Michigan-U.S.A., and Berufsakademie Baden-Wurttemberg & Fachhochschule Baden-Wurttemberg-Germany) and five universities with best practices in Thailand (King Mongkut Institute of Technology-Thonburi, King Mongkut Institute of Technology-Northern Bangkok, Mahanakorn University, Suranaree University of Technology and Rajmongkol University of Technology-Thanyaburi and Bangkok). From the reviews of selected universities and focus group consisting of experts in the field from universities, industry and government, I find the characteristics of technological universities that are relevant to the needs and contexts of Thailand demanding practical technologists and solutions to industrial problems through collaborations as the following:

1. Having educational establishment and basis (vision, missions, goals, objectives, policies and strategies) geared toward science and technology in every level;
2. Emphasizing on generating graduates who serve the dynamic demand of the labour market through teaching and admission priority to graduates of technical colleges/schools who have practical skills and experiences;
3. Having curriculum and education that emphasize learners' skills and capacity that can be applied to the real working world;
4. Having balance between theories and practices in the curriculum;
5. Enhancing collaboration and cooperation among educational institutions, government and industry/private sector in designing, delivering and evaluating the curriculum;
6. Emphasizing research and development through collaboration between universities and industry toward intellectual capital that can be commercialized, applied and developed for potential use
7. Encouraging the university's competitiveness through efficiency and effectiveness in employing and sharing resources;
8. Having or developing administrators and instructors able to bridge theories and practices, realize the demands of industry, apply their previous direct experiences in teaching, learn new context and technology, and develop the potentials of learners to their fullest.

In addition, Thailand's technological university emphasizes individual learning, self-directed learning, life-long learning, team-learning, active learning, project-oriented & problem-based learning and practical research & development through collaboration among universities, industry and government (shown in figure 53)

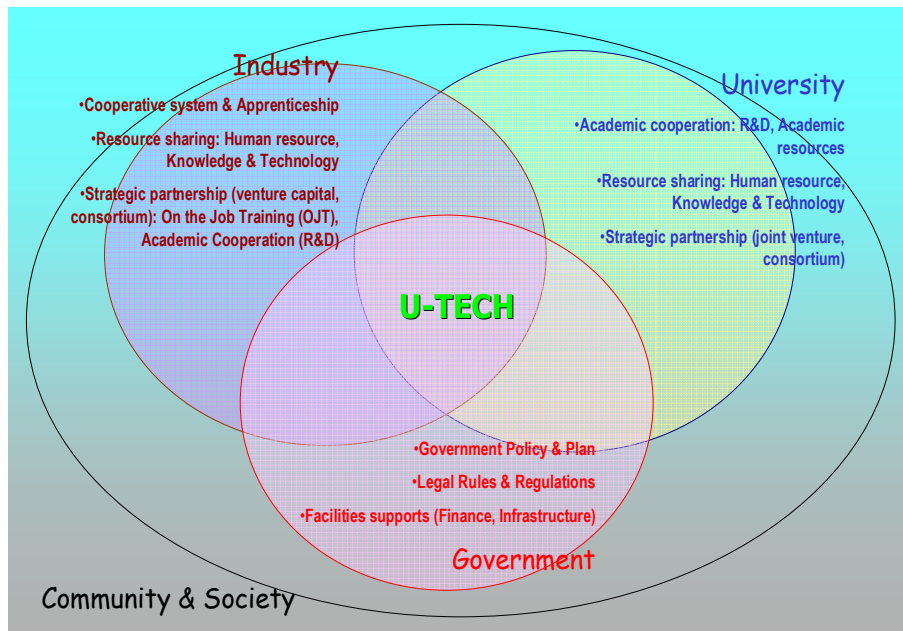


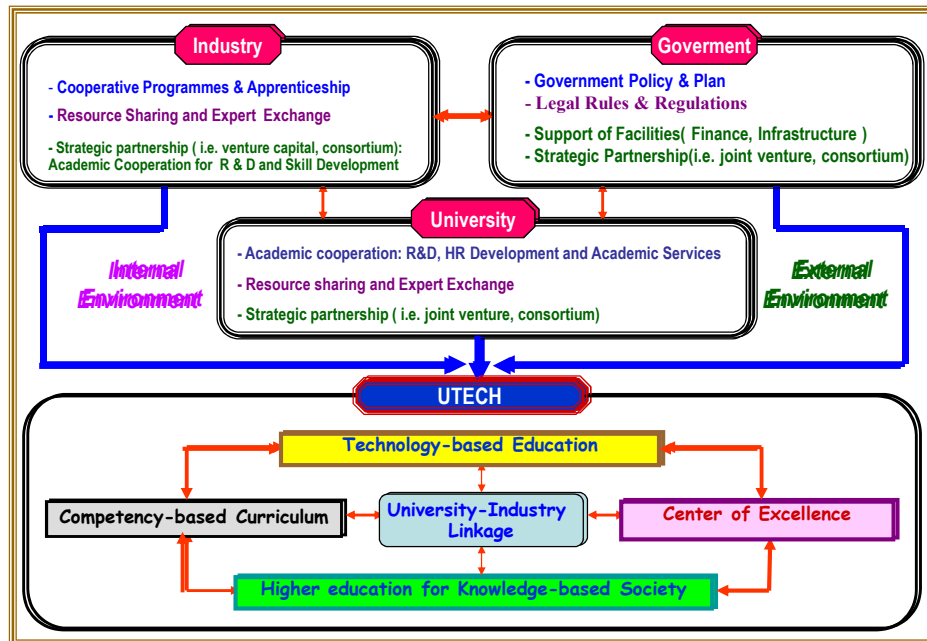
Figure 53: Triple Helix for Industrial Development (adapted from Etzkowitz and Leydesdorff, 2000)

The collaboration of university, industry and government in Figure 1 aims to enhance

1. Knowledge and information related to science and technology that are systematically collected and disseminated for the learning purposes
2. Mechanisms for bridging curriculum development and teaching-learning through the collaboration of the three parties
3. Teaching and learning that supports learners to be able to systematically and practically think, analyze and synthesize.
4. Identification of general education and required course-work that are necessary and relevant to the demands of industry
5. Development of essential skills and competencies: communication, language, computer, self-directed learning, multi-disciplinary/diversity team playing, global skills, analytical skills, creativity, decision-making and problem-solving skills, and other soft skills that serve industry and government policies

Therefore, the technological university that is appropriate to Thailand's contexts is developed under "U-Tech Model" as seen in the figure below (Figure 54)

Figure 54: U-Tech and the U-I-G Model



The “U-Tech Model” is a model that can be either developed in new establishments or employed in an existing university through collaboration with industry and government to serve an industry such as the Thailand’s automotive cluster that is studied in this dissertation.

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